AN ECOLOGICAL ASSESSMENT
OF
CEDARS OF LEBANON STATE FOREST
WILSON COUNTY, TENNESSEE

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Purpose

An ecological assessment of Cedars of Lebanon State Forest was conducted by the Tennessee Division of Natural Heritage in order to provide the Tennessee Division of Forestry with information on the current status and distribution of rare plants and animals, unique features, and habitats, and to provide management recommendations which would enable management of this state forest in a more ecologically sensitive manner.

The mission of the Tennessee Division of Forestry (TDF), Tennessee Department of Agriculture is to protect forest resources and promote their sustainable use through science-based forest management. According to TDF, "Sustainable management emphasizes different uses of the forest in different situations, but always avoids destructive exploitation or lost opportunities due to neglect or ignorance." The mission of the Tennessee Division of Natural Heritage (DNH), Department of Environment and Conservation is to restore and protect the plants, animals, and natural communities that represent the natural biological diversity of Tennessee. Ecological data gathered and maintained by DNH help direct conservation, restoration, and management activities throughout the state.

The target audience of this report is land managers at Cedars of Lebanon State Forest and other staff within TDF. That is not to say the methods and results herein have no use to an academic audience or other land managing agencies, but such use was secondary when the DNH and TDF implemented the materials, methods, and data presentation.

Site Description

Location and Geology

The 7,986-acre Cedars of Lebanon State Forest is located in Wilson County, Tennessee, approximately nine miles south of Lebanon on U.S. Highway 231 and straddles the Vine and Gladeville United States Geological Survey topographic quadrangles. The State Forest is situated within the Central Basin Physiographic Province which is completely surrounded by the Highland Rim. Together, these two physiographic provinces comprise the Interior Low Plateau in Tennessee.

More specifically, the State Forest lies within the Inner Basin which contrasts from the rolling topography of the Outer Basin by its flat topography and surface that often reveals Lebanon limestone (DeSelm 1959). First described by Safford (1869) as Glade limestone, Lebanon limestone is thin bedded with some shale present and fossils are often abundant (Wilson 1980). Caves, sinkholes and disappearing streams are common geologic features of the area. These features are created over time as water runs over the surface and through cracks in the soluble limestone.

Soils and Climate

According to the Wilson County soil survey maps, the major soil type for the State Forest is Gladeville-Talbott-Rock Outcrop. The Gladeville soils of this type are very shallow with a depth of only three to twelve inches before reaching limestone bedrock. These soils are clayey with limestone fragments at or near the surface. The Talbott soils are deeper with a loamy surface over a clayey subsoil. Exposed limestone bedrock forms the flat and nearly soil-level Rock outcrop. The next most common soil

type on the State Forest is Talbott-Gladeville-Bradyville. Bradyville soils are similar to the Talbott except the soils are deeper over the limestone bedrock (Campbell 1996).

The average winter temperature for Wilson County is 38^{o} degrees F with a daily minimum average of 26^{o}. The average daily maximum summer temperature is 88^{o}, but high temperatures above 90^{o} and nearing 100^{o} are not uncommon. The average number frost-free days is 181. Annual precipitation is approximately 52 inches, 50% of which usually falls between April and September (Campbell 1996).

Land-Use History

Prior to Euro-American settlement which began in 1797, Wilson County was inhabited by the Chickasaw, Choctaw, and Shawnee Indians (Campbell 1996). Many more settlers- who gained ownership through land grants as a result of military service during the Revolutionary War-arrived in the early 19th century and found much of the forest dominated by eastern red cedar. Although not a true cedar (genus *Cedrus*), the "cedars" of the area reminded the settlers of the Biblical references (e.g. Psalm 104:16) to the cedars of Lebanon.

Since much of the State Forest has exposed limestone at the surface, and the soils are poorly suited for cultivated crops (Campbell 1996), agricultural clearing, grazing, and lumbering prior to the 1930s lead to erosion and soil depletion. In 1935 the U.S. Forest Service, Works Progress Administration, and the Resettlement Administration began purchasing the land under the Wilson Cedar Project. A few years later the State of Tennessee, under a lease agreement, assumed control of what was then known as the Lebanon Cedar Forest Project and the property was deeded to the State in 1955 (Tennessee Department of Conservation, Division of Forestry 1996). Nearly 900 acres of

the Lebanon Cedar Forest Project is now owned by the Department of Environment and Conservation and managed as a state park (Figure 1). Although applicable to the State Park, this ecological assessment deals exclusively with the land owned by the Tennessee Department of Agriculture, Division of Forestry e.g. the State Forest not the State Park.

Significance

Cedars of Lebanon State Forest has been recognized for its significance as one of the largest tracts of cedar glades and cedar forests in public ownership, including a high number of endemic[1] and rare plant taxa (Baskin and Baskin 1986, Tennessee Division of Natural Heritage 2003B). As a result, a portion of the State Forest was identified by Keever (1971) as a Potential National Natural Landmark and designated as such in 1973. In 1974, 1,041 acres of the 7,986-acre Forest were designated as the Cedars of Lebanon State Natural Area. Presence of the federally endangered Tennessee coneflower (*Echinacea tennessensis*) and high-quality glades led to the additional designations of the Vesta State Natural Area in 1986[2] and Vine State Natural Area in 2000 (Figure 1).

The major plant communities of the inner Central Basin are cedar (*Juniperus virginiana*) glades and barrens, stunted cedar forests, cedar-hardwood forests, and deciduous forests (McKinney and Hemmerly 1984). For clarification this manuscript uses the term "cedar glade" to refer to those habitats with exposed or nearly exposed limestone at the surface, low densities of trees and shrubs, having less that 50% cover of perennial grasses, and with little topographic relief (Figure 2). Glades are considered an edaphic climax in that succession to forest in the absence of burning or other

[1] Restricted to a particular region or location.
[2] Vesta State Natural Area is not wholly contained on the Forest with 60 acres in ownership as part of the State Forest and the remaining 90 owned by the Department of Environment and Conservation.

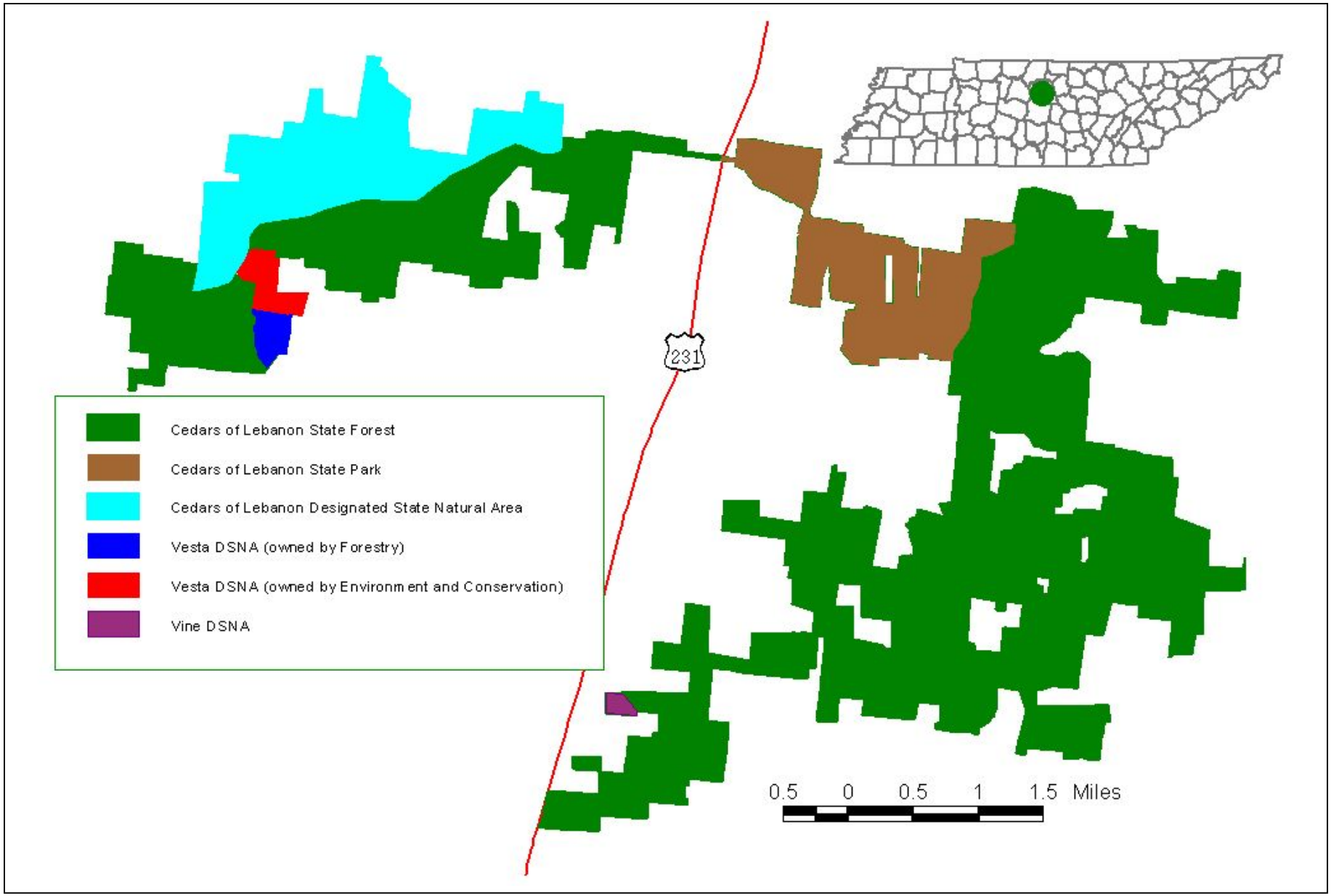


Figure 1. Public Land Ownership of Cedars of Lebanon Complex

management is unlikely (Baskin and Baskin 1999, 2000). This definition is consistent with that used by Quarterman (1989) and Baskin and Baskin (1986, 2003).

It is necessary for the authors to describe another term, "barren", often used in reference to ecology in the Central Basin of Tennessee. Barrens are also predominantly treeless, but differ from glades in that they possess greater than 50% grass cover and have greater soil depths, and thus little to no exposed limestone (Quarterman 1989) (Figure 3). Barrens also differ from glades in that the dominant grass of barrens is the perennial little bluestem (*Schizachyrium scoparium*), while the most common grass on glades is the annual drop seed grass (*Sporobolus vaginiflorus*). Although floristically very interesting, the barrens of the Central Basin often lack the endemic and state and federal listed plant species.

As early as the late 19th and early 20th centuries, geologists noted the substrate and vegetation type of cedar glades (Safford, 1851, 1869, 1884, Killebrew and Safford 1874, Galloway 1919 *in* Quarterman 1950). In the 1901 publication of the *Flora of Tennessee*, Augustin Gattinger wrote a brief floristic description of the cedar glades of the Central Basin, based primarily on those near Lavergne on the Davidson/Rutherford Co. line. Twenty years later, Roland Harper, a naturalist who worked in Georgia and Florida, traveled to Middle Tennessee to visit the cedar glades of which Gattinger wrote. After arriving in Nashville, Harper traveled by rail to Mt. Juliet in Wilson Co. and walked to Hermitage in Davidson Co., visiting and documenting the vegetation of several glades along his route (Harper 1926). Additional studies of glades in the Central Basin followed: Picklesimer (1927) (synthesized in Baskin and Baskin 1996), Freeman (1933),

Figure 2. Cedar Glade with Exposed Limestone

Figure 3. Barren Dominated by Little Bluestem

Quarterman (1950), Somers *et al.* (1986), Drew (1991), Quarterman *et al*. (1993), Drew and Clebsch (1995), Rollins (1997), Baskin and Baskin (2003), etc.

Although cedar glades have been the focus of much of the research and conservation activities in the Central Basin, it is the intent of the authors to focus on the State Forest as a whole, and to offer management recommendations not just for the glades and rare plants therein, but also for other dominant communities and natural features.

Methods and Materials

An initial review of the rare species records in DNH's Biological Conservation Database (BCD) began in the winter of 2002-2003. The BCD contains information on point locations of rare species, their site-specific habitat, directions, the last time the species were observed, etc. The review allowed the authors to determine which species would likely be encountered on the State Forest and to determine which habitats, locations, and times of year to search for rare plants and animals. TDF and DNH agreed that mapping of sinks and other karsts features would be a priority, so topographic maps were reviewed in order to determine high concentrations of such features.

Mapping of Karst Features/Cave Exploration

Mapping of sinks and depressions began in the winter of 2003. All mapping was done with a Garmin GPSMAP 76s global positioning system (GPS). Sinks were identified in the field, GPS points (waypoints) were taken, and staff took notes on the depth, diameter or other features such as the amount of exposed rock or the forest type in which the sink was found. If the sink had a passable entrance or a cave was discovered,

staff made an initial investigation to determine if a future visit was appropriate. If any rare species were observed, field forms were completed and data were entered into BCD.

Karst habitats were a primary zoological focus due to the likelihood of encountering three state-listed animals. These included the eastern woodrat (*Neotoma magister* – deemed in need of management), the southern cavefish (*Typhylichthys subterraneus* – deemed in need of management), and the Tennessee cave salamander (*Gyrinophilus palleucus* – threatened). Additionally, as several protected rare bats could potentially use larger caves for summer roosts, transitional habitats, or hibernacula, bats remained a target of this project as well.

The primary tools for locating survey areas included USGS 1:24,000 topographic maps, published accounts of caves, site information provided by the Tennessee Cave Survey (TCS), and reliable leads provided by TDF personnel. Potential karst areas were then reconnoitered by at least two DNH staff members via pedestrian surveys, primarily conducted in the winter and early spring. All significant features were documented by GPS, generally at the centrum. Staff members then made written observations concerning the approximate dimensions and nature of each cave or sink. If possible, staff entered passable features to determine the subterranean dimensions and to examine the area for rare animals or signs thereof. Certain caves or sinks were targeted for a more thorough reexamination during the fall. Other sites, especially deep pits, were not explored due to limited staff experience with vertical rope work. However, the location of these sites was recorded by GPS and could be explored by experienced cavers at a later time.

When examining subterranean features, staff members used standard safety protocols and common sense to avoid unnecessary risks to life, limb, or to the feature itself. Staff always worked in pairs, and at a minimum wore approved safety helmets, gloves, and kneepads (as necessary), and carried multiple light sources. As needed, staff utilized ropes and/or ladders to permit access to deep sinkholes with the potential for containing significant horizontal passage. Generally, however, purely technical sites, e.g. pits with sheer walls, were not pursued due to time and safety constraints.

Caves vs. Sinks

The karst features documented during this project were assigned to two coarse categories, and were further refined with additional descriptors. "Cave" captures those features generally with large horizontal openings- usually walking, stoop, or crawl passage- and which contain accessible passages that extend beyond the twilight zone (area beyond which no surface light penetrates). The TCS maintains the master list of caves in Tennessee (currently containing 8,491 sites), but requires a minimum of 50' of accessible horizontal passage for a site to qualify as a cave. Thus, a number of Forest "caves" assigned by DNH may not meet the TCS threshold for inclusion in their database.

The assignment "sink" captures all other depressional karst features documented by DNH staff. This includes some features that later qualified as caves, various types of depressions, and pits of different sizes. The following nomenclature was used to further describe sink qualities[3]:

[3] Although DNH included this information in the GIS table, all of the various types are listed as SINK.

Depressions

Depressions were those sinks with gently sloping sides. Often these systems contained little exposed limestone, and were most frequently plugged or closed in the center. Seasonally, those depressions with a significant recharge area were flooded, then dried completely by late summer or early fall. Such features can be extremely important to local amphibian populations, because their periodic drying prevents the establishment of potential fish predators.

Strikes

Limestone trenches (strikes) were common in many parts of the State Forest. Depth varied, but all were accessible without ropes. Some strikes also contained other karst forms noted in this section.

Pits

Pits were those sinks with generally abrupt or sheer vertical walls that could not be scaled without climbing gear, and which were too deep to safely enter without ropes. Pits could be open to view or embedded in other larger sinks. Generally, the recharge area of a pit was extremely limited and often did not extend beyond the rim of the pit itself. For a pit to qualify for TCS listing it must be at least 30' deep; some pits recorded by DNH therefore will not qualify for official listing.

Sinks

True sinks were those features that did not accurately fit into any other category. The pitch of the walls varied, but the base of the sink could be accessed without technical climbing. Usually, extensive exposed limestone was associated with these features. The apparent recharge area varied tremendously, but was generally much less than that associated with depressions.

Sinking Streams

Sinking streams are a common feature on the State Forest. These are normally dry conveyances that only contain flowing water following heavy downpours or after extended wet periods. A sinking stream can terminate in a closed- or open-throated depression, after which point its flow is wholly subsumed by subterranean (phreatic) channels. Sinking streams may also lose substantial flow to karst fractures within the streambed itself, rather than releasing all flow at its terminus.

Tubes

Tubes were caves that were characterized by stoop or crawl passages, some of which were sinusoidal and contained no accessible ancillary passages.

Additional Modifiers

The modifiers "closed-throated" or "open-throated" could be applied to many of the categories noted above. Closed-throated sites were those within which all collected water dissipated only by evaporation or percolation into the soil, either because no drain existed or because it was plugged with detritus or other native material. Open-throated sites contained an obvious, pervious drain into which collected surface water drained into phreatic passages beneath. Certain sinks also contained "lateral" drains as opposed to vertical ones, and were so noted.

Of the organisms that may inhabit caves, troglobitic species are those that are cave-dependent (such as cavefish), while troglophilic species are those that are adapted to cave life but are not obligate cave dwellers (such as woodrats).

Documentation of Other Features

Small glades which were unlikely to be recognized from aerial images were documented so rare plant searches could be conducted later. Throughout all field work, other features such as notably large trees, high-quality plant communities[4], areas in need of management (e.g. barrens, past pine plantations, trash piles, exotic plant infestations), or any other sites which warranted an additional visit were documented. Since the State Forest management plan calls for an undisturbed buffer around cemeteries and old house sites, all such features were noted along with other anthropogenic features (e.g. stone walls).

GPS and GIS Data Management

GPS points were uploaded and converted to an ArcView geographic information systems (GIS) shape file. Field notes relating to each GPS point were transcribed into the shape file's attribute table[5]. The attribute data for each waypoint were given a unique identifier and categorical type. Upon completion of field work, shape files were merged. While in the field the GPS track log (tracing where one has been regardless if a waypoint was taken) was activated and those tracks were also loaded into GIS. This enabled the authors to determine which portions of the State Forest had been surveyed.

Creating a GIS Layer from Archeology Data

In 1979 and 1990 the Division of Archeology documented approximately seventy 19th and 20th century archaeological sites within the State Forest. This site information was recorded on paper and copies were provided to DNH from Forestry staff. DNH staff then entered the geographic coordinates and site names into Excel and ultimately created

[4] A high-quality community is one which shows minimal disturbance or exotic plant infestations and/or a mature forested community of the type which did not seem abundant on the State Forest.
[5] For more complete details or instructions contact the Division of Natural Heritage.

an ArcView shape file[6] for the purpose of relating specific habitat types with past land use.

Digital Images

Digital images were taken throughout the project. All image files were saved in the .jpg format, sorted by general subject, renamed so users could determine image content, and burned to CD.

Rare Plant Surveys

Approximately one-half of the known rare plants on the State Forest flower in March or April (e.g. *Phlox bifida* ssp. *stellaria*), so much of the spring field work was spent searching for new and updating known rare plant populations. Glades and other habitats which were thought likely to contain rare species which flower later in the year (e.g. *Dalea foliosa*) were documented and searched during the summer. Rare species point locations from the BCD were uploaded into GPS units and maps created in order to assist with updating known records. A hardcopy of each rare species record was carried in the field and information as to the description of the site, adjusted latitude and longitude (since a GPS unit was not used to map most of the previous records), more complete directions, etc. was noted and the electronic records updated.

Additional Botanical Work

Although no attempt at a complete floristic inventory (vouchering all vascular plant species) was made, a list was maintained of all vascular plant species observed and the vascular plant list for Wilson Co. (University of Tennessee Herbarium) was consulted for the purpose of collecting previously undocumented species. Contributions to the flora

[6] Electronic data with complete information on these sites and other sites can be acquired from the Division of Archeology, Department of Environment and Conservation.

of Wilson County allow botanists/biologists to better understand the distributions of both rare, common, and exotic plant taxa across the state and region.

A frequency of occurrence designation was used as found in Murrell (1985) and Allowas (1994) which assigns a frequency designator to each species based upon the overall impression of abundance of that species in its habitat. The definitions for each frequency designation are as follows:

Very Rare – A single locality, few individuals
Rare – One or two localities, generally small populations
Scarce – Several localities or scattered small populations
Infrequent – Scattered localities throughout
Occasional – Well distributed but no where abundant
Frequent – Generally encountered
Common – Characteristic and dominant

Plant specimens were pressed, dried, and sent to the herbarium at the University of Tennessee, Knoxville. During the winter karst surveys, selected dominant mosses were collected and sent to Dr. Paul Davison, bryologist at the University of North Alabama, for identification.

Habitat Descriptions

Seven sites were chosen as representative examples of the dominant habitats on the State Forest. These were determined after visiting much of the State Forest for karst mapping and rare species searches. A GPS waypoint was entered for each of these habitat sampling points and data were gathered about the dominant plant species in each stratum (e.g. canopy, understory, ground layer). Additional plants observed were documented, as well as environmental variables such as slope percent, aspect, percent rock, and notable past disturbance. Notes and observations taken when documenting

other features such as sinks or rare species were used to compliment the habitat sampling points.

Moth Sampling

In 1995, Dr. Richard Brown of the Mississippi Entomological Museum, Mississippi State University, began a preliminary survey of moths at selected cedar glades in Tennessee, including six sites on Cedars of Lebanon State Forest (Brown 2003). DNH staff reviewed the report and accompanying collection information in order to determine if any collected moth species warranted addition to the State's rare animal list. Using Brown's site information, DNH created an ArcView GIS table for the six survey sites on the State Forest and for the one site on the State Park. Brown's entire report is located in the Appendix.

Habitat Descriptions

The following descriptions cannot cover all of the 7,986 acres of the State Forest, so it is definite that additional types occur, and that each of the following descriptions could be further divided based upon dominance of a particular species or environmental variable. In addition, plant communities often blend with others and do not allow concrete boundaries, but rather edges or ecotones where one is gradually replaced by another (e.g. the edge of a barrens forming a cedar woodland). Therefore, the following are meant to provide land managers of the State Forest with a description of the dominant plant communities and species likely to be encountered therein.

Cedar Glades

When considering rare plant species, the most significant habitat type found on the State Forest is that of limestone or cedar glades. A cedar glade is perhaps one of the

most easily recognizable habitats. Cedar glades lack a tree canopy, often have exposed limestone at the surface, and the few woody plants which occur are often stunted, or limited to the margins between the cedar glade and the surrounding woodland (Figure 2). For a quick site inspection of a cedar glade, there are many examples along Cedar Forest Road west of U.S. Highway 231.

The high solar radiation and thin soils of cedar glades result in extremely hot and dry conditions in the summer. Such an environment is not suitable for agriculture and thus glades were viewed as waste areas and sometimes used as dumping sites by past (and unfortunately present) area residents. Consequently, many cedar glades-particularly those near roads-have piles of trash such as cans, bottles, or building materials.

Even with the xeric conditions and occasional trash pile, wildflowers of cedar glades can be quite showy. One of the most common wildflowes, found on virtually every cedar glade on the State Forest, is Gattinger's prairie clover (*Dalea gattingeri*) which grows on the open glades on gravelly limestone. Some easily recognizable spring wildflowers include Indian or Nashville breadroot (*Pediomelum subacaule*), rose vervain (*Glandularia canadensis*), star grass (*Hypoxis hirsuta*), and white blue-eyed grass (*Sisyrinchium albidum*). Although a rare plant, glade cleft-phlox (*Phlox bifida* ssp. *stellaria*) is also commonly encountered on the cedar glades of the State Forest. When walking in portions of the glades in the late spring or early summer a mint smell originating from the Ozark calamint/glade mint (*Clinopodium glabellum*) can often be detected.

The differences between dominant flowering species on glades can be quite noticeable between the spring and summer. As previously mentioned, xeric conditions

typify the glades during the warm summers. Many of the spring wildflowers become senescent and are replaced by summer flowering, xerophytic species. Such species include slender false foxglove (*Agalinis tenuifolia*), narrowleaf gum weed (*Grindelia lanceolata*), pasture heliotrope (*Heliotropium tenellum*), and diamond flowers (*Hedyotis nigricans*).

Although quite dry during the summer, the impermeable surface of some glades have areas which possess slow moving or standing water during the wetter months. These "gladey washes" are good locations to search for the federally endangered leafy prairie clover (*Dalea foliosa*) during the summer months and the state threatened yellow sunny bell (*Schoenolirion croceum*) in the spring (Figure 4). Even when neither of these two rare plants is present, the glade spike rush (*Eleocharis bifida*) is regularly encountered in open areas and orange coneflower (*Rudbeckia fulgida* var. *fulgida*) may be found along wooded margins.

While the annual dropseed grass (*Sporbolus vaginiflorus*) is the dominant grass on the rocky interior of cedar glades, the margins of glades and other pockets of thin soil give way to little bluestem (*Schizachyrium scoparium*). Other sites, where the surface limestone has a thin covering of soil, contain patches of woody vegetation. The droughty condition of these habitats yield stunted or gnarled eastern red cedar trees as well as glade privet (*Forestiera ligustrina*) which can form almost impenetrable thickets on the margins of glades or in areas of slightly thicker soil between glades. Also common in these woody thickets and along the glade/forest margin is aromatic sumac (*Rhus aromatica*) and the cedar glade St. Johnswort (*Hypericum frondosum*) while the smaller

Figure 4. Glade Wash with Yellow Sunnybell (*Schoenolirion croceum*)

Figure 5. Tree-of-heaven Infestation in Dry Oak-Hickory Forest

round seed St. Johnswort (*Hypericum sphaerocarpum*) is not restricted to the margins, but is common throughout the glades especially areas of higher soil moisture.

Since the cedar glades are limited to areas of little to no topsoil they also occur along abandoned roadways, current roadsides and old house sites within the State Forest. In fact, these areas, which may be a result of man-induced erosion, have a similar floristic composition as cedar glades within the forest interior. The most accessible example of this is Cedar Forest Road west of U.S. Highway 231 where many rare glade plants are growing just off of the road (e.g. yellow sunnybell, leafy prairie-clover, glade cleft phlox, Ozark downy phlox, white prairie-clover, Tennessee milk vetch)[7].

Barrens

Although warm-season grass dominated habitats can be found on the margins of glades, they are not restricted to such areas and thus warrant a separate habitat description. As previously discussed, a barren is an area with greater than 50% perennial grass cover primarily of little bluestem (Quarterman 1989). Upon first entering a barren area of the State Forest, the visitor will notice a reduction or absence of a tree canopy and a reduction or absence of surface limestone found in the cedar glades[8].

Compared to cedar glades, barrens lack the number of rare plant species and the number of spring flowering plants, yet they do provide an aesthetically enjoyable visit particularly in the summer to early fall. The expanse of little bluestem is a nice backdrop to such flowing plants as butterfly milkweed (*Asclepias tuberosa*), partridge pea (*Chamaecrista fasciculata*), flowing spurge (*Euphorbia corollata*), or the various native

[7] The maintenance of this roadside glade habitat is discussed further in the section on management recommendations.
[8] Field staff estimated one barren on the Forest to have 5% ground cover of surface limestone with a 65% herbaceous cover.

sunflowers (e.g. *Helianthus hirsutus*). Before this inventory, dense blazing star (*Liatris spicata*) had not been documented from Wilson County and although not a rare plant in Tennessee, it has only been found in one barren on the State Forest[9]. This particular site is an excellent example of a barrens ecosystem and during a late July visit there was a fantastic display of butterflies. Even as late as November the barrens on the State Forest yield some interesting flowering plants such as the ladies' tresses orchid (*Spiranthes* sp.)

The most common woody plant in barrens habitat is eastern red cedar which is usually open grown and widely spaced. Many other tree species are present such as post oak (*Quercus stellata*), black oak (*Q. velutina*), blue ash (*Fraxinus quadrangulata*), white ash (*F. americana*), winged elm (*Ulmus alata*), persimmon (*Diospyros virginiana*), and southern shagbark hickory (*Carya ovata* var. *australis*) but individuals are generally stunted or in a small size class.

There has been no lack of publications as to the origin and maintenance of cedar glades and barrens areas (e.g. Baskin and Baskin 2000, Baskin *et al* 1994, Delcourt *et al* 1986). Cedar glades proper are edaphic climaxes kept open by the drought conditions resulting from little to no top soil and high rates of solar radiation (Quarterman 1989), while grass-dominated barrens will likely succeed to a forested habitat without maintenance (Baskin *et al* 1994). The roadside of Cedar Forest Road west of U.S. Highway 231, provides a good example a habitat maintained in early succession. This area is mowed at least semi-annually and the results are a barren area dominated by little bluestem, while the adjacent un-mowed portion is thick with eastern red cedar. Mowing such areas is not the only means of reducing the density of woody plants. Vegetation

[9] This area is located just west of Harris Trail approximately 0.3 mi south of Cedar Forest Road. The unique GIS file name is VEGPLOT6.

monitoring plots established in the State Forest showed a decrease in the density of cedar saplings after a controlled burn (DNH personal observations). Likewise, DNH often uses fire to maintain grassy areas on some of its State Natural Areas.

The encroachment of woody plants in the barrens can be observed on the State Forest. Many barren/hardwood forest edges have a high density of eastern red cedar and as one approaches the center, the density of woody plants decreases while the percent cover of little bluestem increases. These thick cedar stands are a transition to the successional cedar woods described below.

The authors make no claim to solving the dilemma as to the origin or maintenance of barrens, but a few field observations are worth noting. On the State Forest, many of the barrens areas appear to have a clearly delineated boundary with the surrounding forest. Also noted was the absence of the A-horizon[10] in the soil, especially compared to adjacent hardwood forests. Thus it is a possibility that many of the barrens areas had been cleared for agriculture and pasturing in the past resulting in soil erosion. That is not to say that portions of these areas were not naturally open in the past, but had these areas been continually dominated by native grasses it would seem that a thick A-horizon would be present as is the case with the prairies of the Midwest.

Former farms on the State Forest have been abandoned since the Great Depression, and yet there are still areas which have not succeeded to forest. It seems likely that the growth rate of woody plants in the barrens is reduced, and it is possible that these cleared areas-after being planted in crops or pastured for many years-experienced erosion and a loss of nutrients which result in the slow recruitment of tree species (Allard 1942).

[10] The uppermost soil zone, containing humus.

Regardless of their origin, the barrens of the State Forest provide a grassland habitat for a variety of plants and animals, and thus are worthy of maintenance through management by the TDF.

Dry Oak-Hickory Forest

Dry oak-hickory forests may not be as easily categorized as the glades or barrens, yet they can be characterized both in terms of vegetation and habitat, allowing for field recognition. The closed canopy represents varying degrees of dominance of hickories (*Carya ovata* var. *australis*, *C. glabra*, *C. ovalis*), black oak, scarlet oak (*Quercus coccinea*), white oak (*Quercus alba*) and to a lesser extent red oak (*Quercus rubra*). Red cedar is scattered throughout and some patches of this habitat type contain an intermingling of post oak and white ash. Most of the canopy trees are 8 - 12" (20 - 30 cm) diameter at breast height (dbh). Larger chinkapin oaks (*Quercus muehlenbergii*) (and other oak species) are common. These open-grown trees, which range in size from 18 – 28" (~ 45 – 70 cm), appear to have been left during past timbering.

The understory composition of these habitats is highly variable, but there are some characteristic species present such as redbud (*Cercis canadensis*), Carolina buckthorn (*Rhamnus caroliniana*), hackberry (*Celtis occidentalis*), and coralberry (*Symphoricarpos orbiculatus*), with the latter becoming quite dense. Vines such as poison ivy (*Toxicodendron radicans*), grape (*Vitis* spp.), and Virginia creeper (*Parthenocissus quinquefolius*) are common as is the exotic Japanese honeysuckle (*Lonicera japonica*). Although the herbaceous layer is rather sparse, typical species include beaked agrimony (*Agrimonia rostellata*), bedstraw/cleavers (*Galium aparine*), spring avens (*Geum vernum*), and little sweet betsy (*Trillium cuneatum*).

State-listed plants were not easily found in the dry oak-hickory forest, but a few were encountered such as golden seal (*Hydrastis canadensis*), ginseng (*Panax quinquefolius*), and prickly ash (*Zanthoxylum americanum*). Prior to this investigation golden seal had not been documented from Wilson County, so voucher specimens were collected.

Patches of the exotic tree-of-heaven (*Ailanthus altissima*) were occasionally found but where it occurred it was often abundant (Figure 5). Observations indicate that at this time tree-of-heaven is primarily limited to the understory (though a few individuals were found in the canopy) and some individuals appeared to have died back to the surface and resprouted over a period of one to four years. Even with the yearly die-back of some individuals, this species will reach the canopy and become a major problem on the State Forest if left unchecked.

Soils in this forest type have a shallow loamy A-horizon which is primarily covered with leaf litter. The habitat lacks the flat exposed limestone of the glades or the bouldery appearance of the cedar-blue ash woodland (see below), but has exposed limestone around the many sinks and depressions which allow for rapid water drainage and dry conditions.

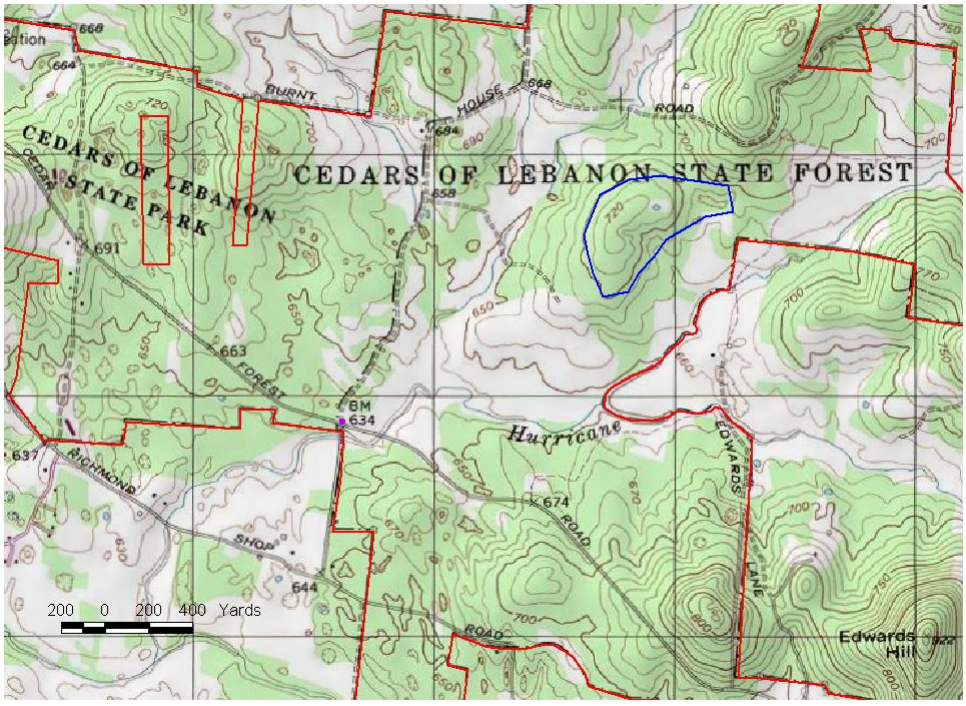
Mature Mixed Forest

A visitor to the mature mixed forest[11] is likely to find this habitat type one of the most visually pleasing on the State Forest. With gently sloping topography, mature trees, more mesic species' assemblage, and open understory, it has a park-like quality allowing one to easily walk through the stands without the aid of trails (Figure 6). This habitat

[11] An easily accessible example of this habitat type is located just north of Cedar Forest Road, 0.8 mile east of Hurricane Creek. The unique value in the GIS coverage provided to TDF is VEGPLOT1.

Figure 6. Mature Mixed Forest with Open Understory

Figure 7. Map Indicating Location of Large Tract of Mature Mixed Forest



primarily occurs on the eastern section of the State Forest in areas of topographic relief and small hills.

Compared with the other forested sites, these areas seem to possess better conditions for tree growth with most of the sites having no exposed limestone at the surface and well-drained soils with an A-horizon of loam. The canopy is dominated by various oak species including red, Shumard's (*Quercus shumardii*), white, and black with southern shagbark hickory. Sugar maple (*Acer saccharum*) grows in the sub-canopy and portions of the canopy, and at some sites is the dominant tree. Canopy trees have straight trunks and are larger than those found in the dry oak-hickory forest. Many trees are greater than 12" (~30 cm) dbh and oaks of 24" (~60 cm) are not uncommon.

Upon entering a stand of the mature mixed forest, it is apparent that there is little to no shrub or sapling layer, and the saplings present consist of tree species such as the shade tolerant sugar maple and American beech (*Fagus grandifolia*). However, sites which showed signs of recent logging (e.g. hardwood stumps and tops) had a high density of sugar maple saplings.[12] Some wildflowers such as limestone bitter cress (*Cardamine douglassii*), May apple (*Podophyllum peltatum*) and little sweet Betsy (*Trillium cuneatum*) can be found in the spring, but the herbaceous diversity, especially in the summer, is minimal with the ground layer consisting primarily of seedlings (particularly redbud and various oaks) and woody vines. Leaf litter covers 80-90 % of the forest floor.

The largest tract encountered during the 2003 field investigations (~ 56 acres) is located on a hill of 660' – 720' elevation on the northeast section of the State Forest (Figure 7). Access is from a horse trail which connects Sue Warren Trail with Burnt

[12] One such site is located on the far southern end of the Forest, 0.5 mi north of Simmons Bluff Road and 0.7 mile east of U.S. 231. Access is provided off of Simmons Bluff Road, and the unique GIS field in the coverage provided to TDF is labeled SINK 249.

House Road Trail. Portions of this oak forest contain Shumard's and red oak, with white oak as the dominant canopy tree species while beech saplings were in the understory. During the spring a pileated woodpecker (*Dryocopus pileatus*) was observed. This distinctive bird is a forest interior species which is more likely to be observed in larger tracts of mature forest (Nicholson 1997). With a flat area atop the hill and gentle slopes, this white oak forest allows for a most pleasant hike.

No rare species were documented from the mature mixed forest, but with its large trees, well developed soil layer, and more mesic conditions this habitat type is unusual on the State Forest.[13]

Cedar-Blue Ash Woodland

Blue ash and cedar share dominance in this habitat type, but their composition varies from site to site with some stands dominated by one or the other species. Trees are usually no larger than 8" (~20 cm) dbh and have a stunted appearance. The shrub layer can be thick in areas consisting of many of the species found on margins of glades (e.g. aromatic sumac, glade privet, cedar glade St. Johnswort) (Figure 8). Cedar stumps protrude from the ground as a reminder of timbering prior to government acquisition in 1930s (TDF. 2003, pers. comm.). Observations indicate that more light reaches the forest floor compared with the other forested communities, likely as a result of the loose foliage of blue ash.

The habitat is flat with exposed limestone comprising 10 + % of the ground layer with much of the remaining surface covered with mosses (e.g. *Pleurochaete squarrosa, Thuidium delicatulum, Climacium americanum*) and lichens (*Cladonia* spp.)

[13] To find out where the highest quality of these sites were documented review the GIS file with the type field = FOREST.

Figure 8. Cedar-blue Ash Woodland with Thick Shrub Layer

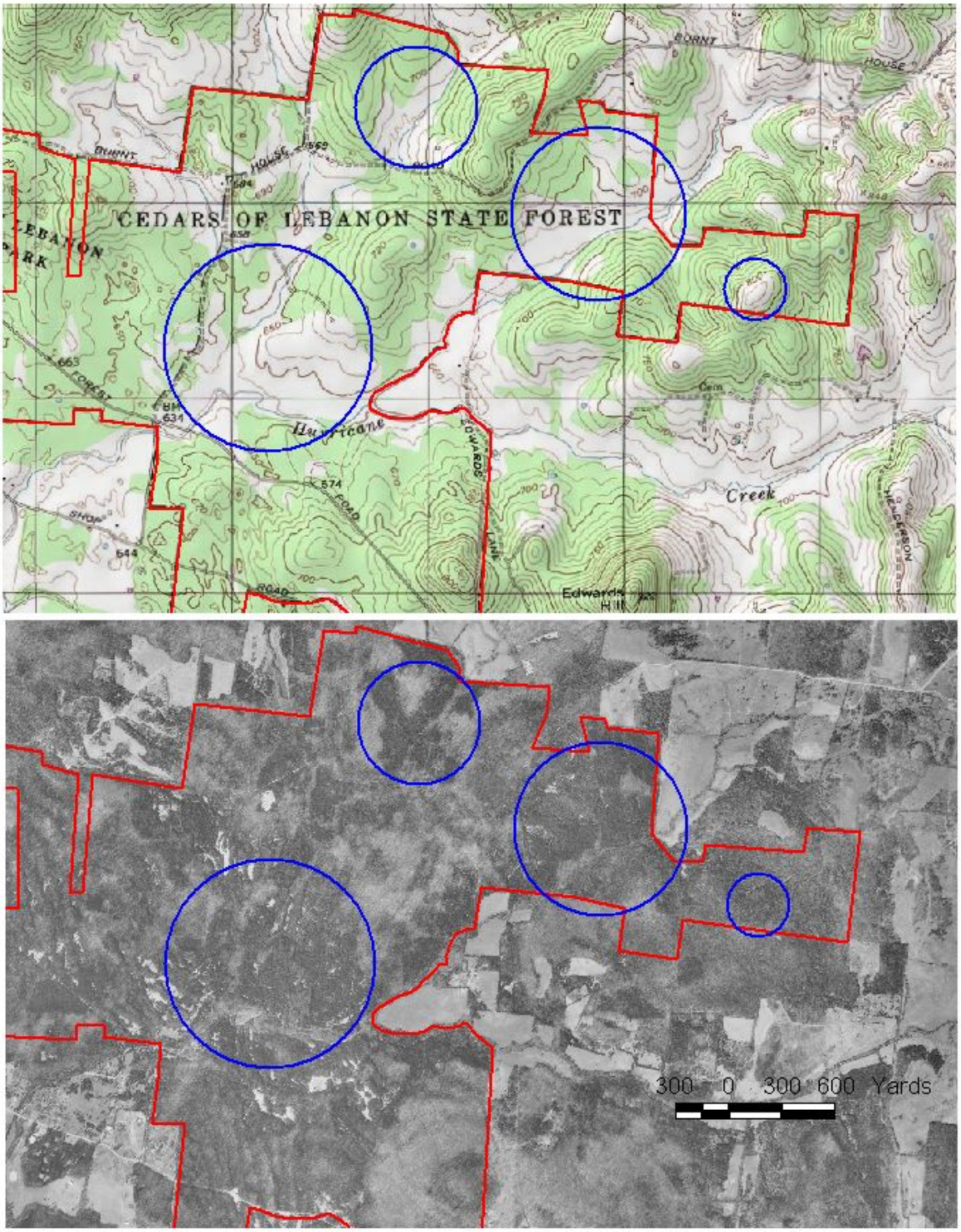
(NatureServe 2003). Soil depth varies reaching 10" in some areas, and soils often have a high organic content and lack the surface clay found in glades and barrens. Herbaceous plants likely to be encountered include American beakgrain (*Diarrhena americana*), lyre-leaved sage (*Salvia lyrata*), Small's ragwort (*Senecio anonymus*), wild petunia (*Ruellia humilis*), and the southern stone seed (*Lithospermum tuberosum*). Patches of Canada leafcup (*Polymnia canadensis*) may dominate the herb layer, completely obstructing one's view of the ground. Portions of these woodlands were more moist in the spring of 2003, and more mesic herbaceous plants such as trillium (*Trillium sessile*), blazing star (*Dodecatheon media*), Jack in the pulpit (*Arisaema triphyllum*) and green dragon (*Arisaema dracontium*) were found. Two rare plant species were documented from this habitat type: the western hairy rockcress (*Arabis hirsuta*), and the Ozark downy phlox (*Phlox pilosa* ssp. *ozarkana*), with the latter also found in other habitat types.

Successional Cedar Woods

Eastern red cedar forms nearly pure stands which are often densely crowded and through which it is difficult to walk. This habitat appears less determined by site conditions and more by landuse history. Examples of this is its occurrence on various sites such as upland hills, edges of successional barrens, and alluvial areas along Hurricane Creek. Topographic maps indicate that these areas were not forested as late as the mid 1970s (Figure 9) and the Division of Archeology survey located old house sites within what is now successional cedar woods.

Having a mossy ground layer, dominance of cedar, and many of the same herbaceous plants, successional cedar woods have similarities to the cedar-blue ash woodland. However, the successional cedar woods often occur in larger tracts, are not

Figure 9. Cedar Forest Succession. As shown by contrast of cleared areas from 1975 topographic map and 1997 aerial photograph



necessarily found in wooded strips between glades and barrens, have an abundance of poison ivy (at one site free standing plants reached 3'), and surface limestone is not as prominent. Coralberry is one of the dominant species in the shrub layer, but saplings of tree species such as sugar maple, chinkapin oak, and blue ash can be found too. Herbaceous species within this habitat are quite diverse across moisture regimes and include Virginia strawberry (*Fragaria virginiana*), flowering sprurge (*Euphorbia corollata*), American beakgrass (*Diarrhena americana*), little bluestem, blisterwort (*Ranunculus recurvatus*), lanceleaf wild licorice (*Galium lanceolatum*) and American lopseed (*Phryma leptostachya*). Unfortunately, the dominant herbaceous plant in this type of habitat along Hurricane Creek is the invasive exotic Nepalese grass (*Microstegium vimineum*). Often horticultural plantings such as common periwinkle (*Vinca minor*), iris (*Iris* sp.), and stonecrop (*Sedum* sp.) persist in areas with historical human inhabitation.

Former Pine Plantations

Portions of the State Forest contain recently harvested stands of loblolly pine (*Pinus taeda*), a species native to areas further south than Wilson County, but widely planted as a pulpwood and timber species (Flora of North America 1993). These past cuts are scattered on the State Forest including areas within the Cedars of Lebanon Designated State Natural Area. Seven of the twelve former pine plantations documented by DNH occur adjacent to 19th and 20th century house sites[14] which may explain the eroded clay soils with minor amounts of exposed rock. One such example is located in

[14] This was determined by using the GIS layer created from data provided by the Division of Archeology.

the southeast portion of the State Forest at the intersection of Cedar Forest Road and the Harris/Arnold Trail[15].

Identifying characteristics of these former pine plantations include open areas which appear "weedy" due to herbaceous plants covering up to 75% of the surface. Some hardwood saplings and a few trees (e.g. white ash, sassafras, winged elm) are loosely scattered throughout. Dense thickets of blackberry bushes (*Rubus* spp.) combined with the remaining slash can make these areas difficult to traverse on foot. Exotic plants such as Queen Ann's lace (*Daucus carota*), sericea lespedeza (*Lespedeza cuneata*) and Japanese honeysuckle are common. However, many native plants such as Cherokee sedge (*Carex cherokeensis*), cypress panic grass (*Dicanthelium dichotomum*), frostweed (*Verbesina virginica*), *Aster* spp., and little bluestem occur.

Botany/Flora Notes

The flora of Cedars of Lebanon is an interesting cross-section of the flora of southeastern United States and Tennessee. Much of the flora is influenced by the abundance and diversity of limestone cedar glade and barren habitats. Many of the species associated with these glade/barren communities are both regionally and globally restricted to Middle Tennessee. Glade cleft-phlox is only known from three counties in Tennessee but is locally abundant on the State Forest. Likewise, Nashville breadroot, Tennessee milk-vetch (*Astragalus tennesseensis*), limestone fame flower (*Talinum calcaricum*), and Gattinger's prairie-clover are all geographically restricted to limestone cedar glade habitats, but are locally abundant. On the other hand, with the lack of mesic community types many of the widespread and common species in Tennessee such as

[15] For additional locations consult the GIS table and search for type equal to "RESTORE."

paw-paw (*Asimina triloba*), sycamore (*Platanus occidentalis*), blue phlox (*Phlox divaricata*), May apple (*Podophyllum peltatum*), and broad beech fern (*Phegopteris hexagonoptera*) are scarcely found on the State Forest.

A total of 340 species of vascular plants were documented by observation and/or vouchers. This floristic inventory list is by no means complete for numerous collections over several years would be needed to complete the vascular plant flora. Of the 340 species documented, 78 were vouchered as county records (Table 1). Many of the county records are widespread in the state, such as giant cane (*Arundinaria gigantea*) and box elder (*Acer negundo*). Others represent range extensions for rare species such as goldenseal (*Hydrastis canadensis*) and low nut rush (*Scleria verticillata*).

Based upon Dr. Paul Davison's identification, fifteen bryophytes were documented from the State Forest (Table 2). Additional bryophyte inventory is suggested on the State Forest and surrounding cedar glade ecosystems. During this project only the common, conspicuous species of bryophytes were collected for identification.

The need for additional botanical work cannot be overemphasized. Collection of 78 county records in one calendar year by DNH staff is indicative of the lack of floristic attention the area has received in the past. Middle Tennessee possesses a biological resource unique in the world as represented in the limestone cedar glades with their abundance of endemic plant species (Quarterman 1989).

Exotic Plant Species

A total of 30 exotic plant species were documented on the State Forest (Table 1). An exotic plant species is defined here as a plant that is present but has been introduced

to the Middle Tennessee area outside of its native range. The primary concern surrounding these species is they represent a possible management concern as invaders of natural communities. Six documented exotic plant species are listed as "Rank 1- Severe Threat" by the Tennessee Chapter of the Exotic Pest Plant Council (TN-EPPC). Severe Threat is defined as "exotic plant species that possess characteristics of invasive species and spread easily into native plant communities and displace native vegetation; includes species that are or could become widespread in Tennessee" (Tennessee Exotic Pest Plant Council 2001). Severe threat species include tree-of-heaven, sericea lespedeza, Chinese privet (*Ligustrum sinense*), bush honeysuckle (*Lonicera maackii*), Japanese honeysuckle, and Nepalese grass (*Microstegium vimenium*). These species are expected to persist, reproduce and increase their numbers on the State Forest.[16]

Seven non-native invasive plants listed as "Rank 2 – Significant Threat" were documented. A Significant Threat is defined as "exotic plant species that possess characteristics of invasive species but are not presently considered to spread as easily into native communities as those species listed as Rank 1" (Southeast Exotic Pest Plant Council 2003). The species documented include Japanese brome (*Bromus japonicus*), musk thistle (*Carduus nutans*), crown vetch (*Coronilla varia*), Queen Anne's lace, white sweet clover (*Meliotus alba*), yellow sweet clover (*M. officinalis*), and periwinkle (*Vinca minor*). These species show some ability to invade limestone cedar glade and barrens communities with or without disturbance.

Finally, two non-native species were documented and listed as "Rank 3 – Lesser Threat" and one plant listed as "Watch List A." Lesser threat is defined as "Exotic plant species that spread in or near disturbed areas; and are not presently considered a threat to

[16] Exotic plant infestations are identified in the GIS table and labeled EXOTIC.

native plant communities." Chicory (*Cichorium intybus*) and goatsbeard (*Tragopogon dubius*) are representatives of this group found on the State Forest. The Watch List A is defined as " Exotic plants that naturalize and may become a problem in the future" (Southeast Exotic Pest Plant Council 2003). Thorough wax (*Bupleureum rotundifolium*) was the only Watch List A species found and could have a tendency to invade limestone cedar glade habitats.

Additional non-native species were documented but are indicative of roadside habitats and can be considered agricultural weeds. These include orchard grass (*Dactylis glomerata*), false daisy (*Eclipta prostrata*), shaggy soldier (*Galinsoga quadriradiata*), and beefsteak plant (*Perilla frutescens*).

Rare Plants

Prior to this survey, twelve rare plant species comprising 98 occurrences were known from the State Forest. The 2003 field investigations yielded three additional rare species, 88 new occurrences, and 35 updates to existing rare plant records. Eleven of the fifteen rare plant taxa (Table 3) are indicative of limestone cedar glade habitats, while only golden seal, ginseng, Ozark downy phlox (*Phlox pilosa* ssp. *ozarkana*), and prickly ash (*Zanthoxylum americanum*), occur in forested communities. Two rare plant species (Tennessee coneflower and leafy prairie-clover) are federally endangered. Three rare plants were determined to be county records for Wilson County: low nut rush (*Scleria verticillata*), goldenseal, and prickly ash.

Three plant species (glade cleft-phlox, limestone fame-flower, and Tennessee milk-vetch) account for almost two-thirds (64%) of the rare plant occurrences on the State Forest. Although commonly encountered due to the abundance of glade habitat,

these species are geographically restricted to the southeastern United States. Discussion on each rare plant species documented from the State Forest will be treated in the following subsections.

***Arabis hirsuta* (western hairy rockcress)**

A member of the mustard family (Brassicaceae), western hairy rockcress is known from only three counties in Tennessee, two of which are in the Central Basin. It ranges from Quebec west to British Columbia south through California and east into Georgia occurring on limestone ledges, woods, and hillsides. It appears to be widespread, but rare in the southern and eastern portion of its range and is listed as a threatened species in Tennessee (Tennessee Division of Natural Heritage 2003A).

Unlike many of the other rare species on the State Forest, the western hairy rockcress does not occur on open limestone cedar glades. The two known locations had a limestone substrate, but differing moisture regimes. One occurrence was in a successional blue ash-cedar woodland in a moist, karst bottomland along a creek. Sunlight resulting from a canopy gap was favorable for the species at this site, but competition from other herbs and glade privet may be detrimental to its long-term persistence. The second occurrence was in a dry red cedar stand along the margins/ecotone of a limestone cedar glade and hardwood forest. The two habitats in which western hairy rockcress was found are common in the State Forest, but with only two populations its requirements are not well understood.

***Astragalus tennesseensis* (Tennessee milk-vetch)**

Tennessee milk-vetch is a member of the pea family (Fabaceae) and is known from eight central basin counties in Tennessee. The global distribution for Tennessee

milk vetch is considered bicentric, in that it is known from the cedar glades of Middle Tennessee and northern Alabama, and from Illinois (extirpated in Indiana) (Baskin *et al* 1972). Across its range, it is most abundant in Middle Tennessee with 245 documented occurrences. Based on this restricted geographic range, the conservation of this listed, special concern species in Tennessee is critical to its global existence.

Tennessee milk-vetch is found along the margins of limestone cedar glades and barrens, and tends to be associated with trails, road sides (i.e. Moccasin Road, Cedar Forest Road), and other disturbed areas on glades. Occasionally, plants occur on isolated glades but such populations contain small numbers of individuals. Based strictly on observation on the State Forest, the species tends to benefit from occasional disturbances and may use trails, roads, etc. as a means of dispersing its seeds.

***Dalea candida* (white prairie-clover)**

White prairie-clover is a member of the pea family (Fabaceae) and is known from six counties in Tennessee. In the Central Basin it is associated with rocky limestone cedar glades and barrens. Its distribution is widespread throughout the upper Midwest, south to Texas and Louisiana, east to Middle Tennessee and Georgia. It is listed as special concern in Tennessee due to its geographical distribution and restricted habitat (Tennessee Division of Natural Heritage 2003A).

Searches for the previously known population on the State Forest were unsuccessful, but one new population was located. This large population occurs along Cedar Forest Road east of U.S. Highway 231. Mowing along this roadside in the fall will benefit the long-term existence of this population and may allow the species to spread over time (see management recommendations below). With only eleven extant

occurrences in Tennessee and one on the State Forest a conscious effort should be made to locate additional occurrences and to maintain the current population.

***Dalea foliosa* (leafy prairie-clover)**

Leafy prairie-clover is a member of the pea family (Fabaceae) and occurs in six counties in Tennessee, all in the Central Basin. Much like Tennessee milk-vetch, leafy prairie-clover has a bicentric distribution in the eastern U.S. The species is nearly endemic to the limestone cedar glades and barrens of Middle Tennessee and northern Alabama with just a few disjunct occurrences in Illinois, where it is restricted to the limestone prairies along river terraces (U.S. Fish and Wildlife Service 1996). Leafy prairie-clover was listed by the U.S. Fish and Wildlife Service (USFWS) as federally endangered in 1991; likewise, it is listed as endangered by the state of Tennessee (Tennessee Division of Natural Heritage 2003A).

Leafy prairie-clover occurs on open limestone cedar glades and barrens usually associated with an ephemeral creek or wash (i.e. gladey washes). Since the species is federally listed, DNH focused inventory efforts to relocate known occurrences. Nine of eleven previously known occurrences were updated, and three new occurrences were found. The presence of other rare indicator species in these gladey washes, such as yellow sunnybell and low nut rush, indicates the significance of this unique habitat on the State Forest.

Most of the occurrences of leafy prairie-clover are small but stable, comprised of 50 plants or less. Data from a few smaller occurrences show numbers of plants remaining stable over an eight to ten year period (Tennessee Division of Natural Heritage 2003B), and such occurrences need to be closely monitored and updated regularly. It is

unclear if the species was historically more widespread in the areas of the known occurrences, and little is known as to how land use prior to public ownership affected this species.

***Echinacea tennesseensis* (Tennessee coneflower)**

Tennessee coneflower is a member of the composite family (Asteraceae) and is known from only three counties in Middle Tennessee where it is endemic and restricted to limestone cedar glades and barrens, exclusively within the Stones River Watershed. The species is closely related to, and may be considered a variety of, pale purple conefower (*E. pallida*) (Binns, *et al*. 2002). In 1979, the USFWS listed the Tennessee coneflower as endangered; likewise, it is listed as state endangered in Tennessee (Tennessee Division of Natural Heritage 2003A).

McGregors' 1968 monograph on the genus *Echinacea* considered Tennessee coneflower to be possibly extinct. Ironically, it was rediscovered by Quarterman and Hemmerly in Davidson County that very year (Quarterman and Hemmerly 1971) and in 1970 they located Tennessee coneflower on the State Forest, extending the species' known range. The State Forest site is considered the first documented occurrence of Tennessee coneflower on public property and it represents a viable refuge for this globally rare and endemic species for future generations to study and enjoy.

To date there are a total of eleven occurrences known from the State Forest, four of these were first documented in 2003, and three others were updated. Six of the ten occurrences are introduced colonies, and at least one such colony (Element Occurrence Record #036)-planted by Paul Somers, former botanist with DNH-has become dominant along the margins of an open limestone cedar glade. Introductions of Tennessee

coneflower onto protected property have been successful in the past, and the State Forest has an abundance of relatively isolated cedar glades and barrens which could make excellent future introduction sites.

***Evolvulus nuttallianus* (shaggy dwarf morning-glory)**

The Shaggy dwarf morning-glory (*Evolvulus*) is a member of the morning-glory family (Convolvulaceae) and in Tennessee is known from Wilson and Rutherford Counties with all but one occurrence in the Stones River Watershed. Its distribution is primarily midwestern from North Dakota to Colorado south to Missouri, Kansas and Texas. The species is listed as special concern in Tennessee primarily due to its disjunct distribution into Tennessee and rarity of habitat.

Of the seven known occurrences on the State Forest, only one was relocated and no new populations were found. DNH did expect to find more *Evolvulus* given the abundance of limestone cedar glade habitat and there are numerous occurrences in the vicinity of the State Forest. It is possible that *Evolvulus* was overlooked during these field investigations, but its easily recognizable dusty gray appearance makes this seem unlikely. Given the abundance of potential habitat on the State Forest, the species appears to be very rare.

***Hydrastis canadensis* (goldenseal)**

Goldenseal is a member of the buttercup family (Ranunculaceae) and is found widespread in Tennessee and across the eastern U.S. Commercial exploitation by the removal of plants from the wild to sell as an herbal product has lead to a concern that the species may be in decline. As a result, Tennessee DNH lists goldenseal as a species of special concern (Tennessee Divisions of Natural Heritage 2003A).

The habitat for goldenseal is described as rich mesic forests in coves, north-facing slopes, usually on limestone derived soils. Such habitat is poorly represented on the State Forest where only three occurrences of goldenseal are found. Their locations in open, dry to slightly mesic cedar hardwood forests are similar to that described from Oak Ridge Reservation (Parr 1984). Although there is minimal rich forest habitat, there is no shortage of dry cedar hardwood forests on the State Forest and goldenseal may be more abundant than originally thought. The occurrence of goldenseal on the State Forest represents a county record for Wilson County and a voucher specimen has been sent to the University of Tennessee Herbarium.

***Leavenworthia exigua* var. *exigua* (Tennessee glade-cress)**

Tennessee glade-cress is a member of the mustard family (Brassicaceae) and in Tennessee is known from eight Central Basin counties and two Western Highland Rim counties. Outside of Tennessee it is only known from one county in northern Georgia. It is a limestone cedar glade indicator species but, on occasion, can be found in areas of disturbance. Tennessee DNH tracks the species as special concern due to its indication of rare cedar glade habitat (Tennessee Division of Natural Heritage 2003A).

Numerous *Leavenworthia* species dominate the open limestone cedar glades in the early spring. *Leavenworthia stylosa* (cedar glade-cress), *L. torulosa* (necklace glade-cress), *L. unifolia* (Michaux's glade-cress) and Tennessee glade-cress may occur together and produce a showy, fragrant display in the cedar glades. Cedar glade-cress is by far the most common *Leavenworthia* on the State Forest and frequently occurs with Tennessee glade-cress, but the two species are difficult to distinguish in flower and Tennessee glade-cress may be over looked in the presence of cedar glade-cress.

Prior to this investigation, only two occurrences of Tennessee glade-cress were known from the State Forest, but six new occurrences were documented in 2003. It is likely that this species is more common and widespread across the State Forest, but proper identification can be difficult for the fruit is needed to distinguish it from other *Leavenworthia* species.

***Panax quinquefolius* (ginseng)**

Ginseng is a member of the ginseng family (Araliaceae) and is found widespread across Tennessee and the eastern U.S. As with goldenseal, ginseng is listed as special concern in Tennessee due to it commercial exploitation as a folk remedy and herbal commodity (Tennessee Divisions of Natural Heritage 2003A). It is feared that the species is in decline due to an overwhelming collection pressure and slow reproductive capacities.

Consistent with the species' typical habitat, the two known occurrences of ginseng on the State Forest were found in a rich, mesic oak forest near a sinkhole on the far west side. Due to shading and adequate moisture, the numerous large sinkholes scattered across the State Forest offer potential habitat for ginseng. Additional occurrences are likely, but the abundance of herbaceous growth in the understory may impair one's abilities to recognize the plant. Since buffers are placed around sinkholes in forestry practices, these habitats appear to be fairly static, and therefore favorable for ginseng.

***Phlox bifida* ssp. *stellaria* (glade cleft-phlox)**

Glade cleft-phlox (Phlox) is a member of the phlox family (Polemoniaceae) and is known from three counties in Tennessee all within the Central Basin. Phlox is

considered rare throughout its range, which includes Indiana, Illinois (extirpated), Missouri, Arkansas, Kentucky and Tennessee, where it is listed as threatened and occurs exclusively within the Stones River Watershed (Tennessee Division of Natural Heritage 2003A). Phlox is an indicator of limestone cedar glade habitats where it occupies the margins dominated by thinly scattered red cedars and square pluerocheate moss (*Pleurocheate squarrosa*).

Phlox was the most frequently encountered rare plant species on the State Forest. In 2003, DNH documented 27 new occurrences and updated eleven previously known occurrences, bringing the total known occurrences on the State Forest to 47. These occurrences represent approximately 30% of the known occurrences of Phlox within the state of Tennessee.

Phlox readily invades gladey roadsides, open trailsides and other disturbed areas on the State Forest. It also occurs on isolated limestone cedar glades. The most accurate way to describe the distribution of Phlox on the State Forest is locally, very abundant. In the spring, the species produces scenic displays of dusty lavender along sections of Cedar Forest Road both east and west of U.S. Highway 231. The State Forest provides a valuable refuge for this species in Tennessee and throughout its known range.

***Phlox pilosa* ssp. *ozarkana* (Ozark downy phlox)**

Ozark downy phlox is a member of the phlox family (Polemoniaceae) ranging from Missouri to Kansas south to Louisiana and only as far east as Tennessee. Known from only five counties in Tennessee, Ozark downy phlox is listed as a taxon of special concern due to a poor understanding of its distribution and questionable varietal recognition (Tennessee Division of Natural Heritage 2003A).

The five known occurrences (four located in 2003) on the State Forest are typically comprised of only a few flowering individuals found in dry, thinly forested successional cedar-blue ash woodlands. Since it is also found on roadsides adjacent to forested habitats, the frequency of occurrences may increase with the increase in successional communities associated with disturbances from pine removal.

Ozark downy phlox can be distinguished from the common downy phlox (*Phlox pilosa* ssp. *pilosa*) by the somewhat heart-shaped leaf bases, and gland tipped hairs on the upper leaves and stems (Steyermark 1963). Since the common downy phlox was not observed on the State Forest, any deep rose-lavender phlox on the State Forest should be considered the Ozark downy phlox unless proven otherwise.

***Schoenolirion croceum* (yellow sunnybell)**

Yellow sunnybell is a member of the lily family (Liliaceae) ranging primarily along the coastal plain from North Carolina to Texas, inland only to Tennessee. Known from only five Central Basin counties, it is listed as a threatened plant species in Tennessee because of its geographical rarity and its indication of moist, swaley limestone cedar glades (Tennessee Division of Natural Heritage 2003A). DNH located seven occurrences on the State Forest bringing the total number of known occurrences to eleven. With all but one occurrence consisting of more than 50 individual plants, yellow sunnybell populations seem quite healthy.

This plant species has specific habitat requirements within the limestone cedar glade ecosystems in that it typically occupies wet/seepy, slowly draining limestone cedar glades which are often saturated early in the year (Figure 4). Of the habitats harboring rare plant species on the State Forest, these open, seepy limestone cedar glades are the

most fragile and thus extremely sensitive to disturbance from horses, all terrain vehicles (ATVs,) and off-highway vehicles (OHVs). This unique habitat yields floristic associations distinct from the surrounding drier glades and includes such species as glade spike rush (*Eleocharis bifida*), Crawe's sedge (*Carex crawei*), leafy prairie-clover (discussed above), low nut rush, and fluxweed (*Isanthus brachiatus*).

***Scleria verticillata* (low nut rush)**

Low nut rush is a member of the sedge family (Cyperaceae) and is known from only three Middle Tennessee counties. It is listed as a species of special concern in Tennessee due to the rarity of habitat and its geographical distribution within and outside the state (Tennessee Division of Natural Heritage 2003A). Low nut rush is associated with fragile calcareous fen habitats of the upper Midwest, and Atlantic and Gulf of Mexico coastal areas in the Southeast. The destruction of its habitat has lead to a decline in the species throughout its range (Coffin and Pfannmuller 1988).

Within Tennessee, there are only seven known occurrences, most of which are associated with wet/seepy limestone cedar glades. For information on such habitats, their rarity, and susceptibility to disturbance see the above section on yellow sunnybell.

The newly documented occurrence of low nut rush on the State Forest represents a Wilson County record. Due to the difficult identification of members of the sedge family, the plant was collected and identified at a later date, and additional occurrences may have been overlooked.

***Talinum calcaricum* (limestone fame-flower)**

Limestone fame-flower (*Talinum*) is a member of the Purslane family (Portulaceae) and an endemic plant known only from the cedar glades of northern

Alabama and Middle Tennessee where it occurs in nine counties in the Central Basin (Ware and Quarterman 1969). Due to this limited geographic distribution and because of its indication of limestone cedar glades, it is listed as a species of special concern in Tennessee (Tennessee Division of Natural Heritage 2003A).

Talinum seems to be a pioneering species as it typically occurs in fissures of solid limestone bedrock and in shallow gravels over bedrock with very little herbaceous competition. Its typical associates are cedar glade-cress, Pitcher's sandwort (*Arenaria patula),* and widowscross (*Sedum pulchellum*), although these species' presence vary seasonally. The habitat is extreme in that the substrate can be saturated and periodically holding water in the winter and spring, while harshly xeric in the summer. These harsh summer conditions allow *Talinum* to be the only native plant actively growing in the shallow gravels and soil over limestone through May to late September (Ware 1969).

DNH documented thirteen occurrences (eight new and five updates) of *Talinum* bringing the total number of known occurrences on the State Forest to 32. Additional occurrences may have been overlooked, because much of the rare plant survey work was done in the spring when *Talinum* is less recognizable and in an underdeveloped state compared to the summer. The species appears to be secure across its range in Tennessee and is frequently encountered in open limestone cedar glade habitats both on and off the State Forest. Recent mild disturbance to cedar glade habitats may actually benefit the species in the short term.

***Zanthoxylum americanum* (prickly ash)**

Prickly ash is a member of the rue family (Rutaceae) and is found primarily in the northern half of the U.S. and Canada, as well as scattered localities south of the Ohio

River. Known from five counties in Tennessee, it is listed as a species of special concern due to its geographical distribution outside of Tennessee (Tennessee Division of Natural Heritage 2003A). In Middle Tennessee, prickly ash is associated with karst cedar/hardwood forests and fence rows.

Prickly ash was unknown from Wilson County prior to DNH documenting two occurrences on the State Forest. The plant typically forms thickets of trees 6-10 ft tall, but those on the State Forest were only 1-2 ft tall and seemed to be heavily browsed by deer. Since all the prickly ash observed were very small and contained no fruits or flowers, it is possible that it is not reproducing but merely maintaining itself in a vegetative manner. Other occurrences are likely to exist but may have been overlooked in the past, for it is the impression of DNH that many of the forested communities have not received the same botanical inventory efforts as the adjacent limestone cedar glades.

Additional Rare Plants

In addition to the fifteen rare plant species documented, there are a few additional rare plants which may occur on the State Forest. These rare plants include Carolina anemone (*Anemone carolinana*), violet prairie-clover (*Dalea purpurea*), white four-o-clock (*Mirabilis albida*), tansy rosinweed (*Silphium pinnatifidum*), and running glade-clover (*Trifolium calcaricum*). Carolina anemone occurs on Cedars of Lebanon State Park and thus likely occurs on the State Forest, and early spring surveys would be necessary to confirm this. Violet prairie-clover, white four-o-clock, and tansy rosinweed are located on the adjacent TDEC land of the Vesta Cedar Glade State Natural Area, and based on potential habitat, these four species could likely occur on the State Forest. If they currently do not occur, they could spread into available habitat.

Finally, running glade-clover is located south of the State Forest in Rutherford, Marshall, and Bedford counties and could likely occur in cedar-blue ash woodland and margins of glades. Although not documented, a conscious effort was made to search for this species, and since there is an abundance of potential habitat the occurrence of this species on the State Forest is possible.

Animal Species

Prior to beginning rare animal surveys, six rare species were known on or near the State Forest (Table 5). Because the greatest opportunity to locate known listed species on the State Forest centered on troglobitic or troglophilic organisms, the primary focus of zoological surveys was on the karst resources of the site.

Moth Data from Mississippi State University

As noted in the report submitted by Dr. Richard Brown, numerous potentially rare moth species were documented from the State Forest (Brown 2003). Although none of the species documented by Dr. Brown is currently listed by the USFWS (and cannot be legally listed by the State), a tremendous amount of the State Forest's biological diversity is represented by this group of insects. Because of the intimate relationship between moths and their food and nectar plants, the diversity of rare plant taxa may have a strong influence on the moth community. With over 500 species collected on the State Forest and surrounding environs during a relatively limited study by Dr. Brown, the area could prove to have one of the most diverse moth assemblages in Tennessee.

Of the notable species reported by Dr. Brown, most are considered by NatureServe® to be abundant and secure rangewide. Two, however, are believed rare

rangewide, and both are listed as rare species by at least one adjoining state. *Nemora tuscarora* Ferguson, a geometrid moth, is tracked in both Virginia and North Carolina, and is known from fewer than ten sites in only five other states. One specimen each was collected from the State Forest and the State Park during Dr. Brown's study. *Argillophora furcilla*, a noctuid moth likewise tracked in Virginia and North Carolina, is reported from North Carolina to Georgia and Mississippi, and is considered rare range-wide. One specimen was collected from the State Forest. Although numerous moth species may appear to be rare because of under-collecting or obscurity, these two species appear substantively uncommon and will probably be tracked as rare species by DNH.

Rare Animal Species

At present, based on recent rare animal records and current observations, five state-listed species occur on the State Forest or in close proximity to it. These include two birds, one mammal, one salamander, and one fish species. Each is described individually, below:

Gyrinophilus palleucus (Tennessee cave salamander)

Although the Tennessee cave salamander (state threatened/federal management concern) has not been documented on the State Forest, its presence on the Cedars of Lebanon Park and in the Rockdale community suggests that the species almost certainly will be found beneath the Forest. This reclusive troglobitic species likely occupies portions of the phreatic system that cannot be accessed by investigators. Because only a few caves are large enough to allow access to perennial subterranean streams- and then only small stream segments- the fact that the species has not been observed is not

surprising. Considerable time and effort will be necessary to confirm the presence of the salamander.

Currently, *G. palleucus* is recognized as three distinct and geographically isolated subspecies (*G. p. palleucus, G. p. necturoides, and G. p. gulolineatus*) in Tennessee. One subspecies, *G. p. palleucus*, is also reported from Alabama and small portion of Georgia. A fourth potential subspecies, the "Central Basin form," is recognized from Rutherford and Wilson Counties (Petranka 1998). Certain authors have regarded some of the subspecies worthy of elevation to species status, and this probably will occur after the genetic relationships between the different populations have been determined.

The Tennessee cave salamander is neotenic, meaning that individuals become sexually mature in a larval form. They retain their external gills throughout life, only rarely metamorphosing in nature (Petranka 1998). This stout-bodied species can reach up to 9" in length, and feeds opportunistically on other cave organisms, principally invertebrates. Their coloration varies, but generally they are light brown with darker brown spots dorsally, but can also express a distinctly pink tint (Figure 10). The Central Basin form is most closely associated with sinkhole-fed caves, which are abundant on the State Forest.

Although this species is currently listed as threatened in Tennessee, elevation of its status to endangered by the Tennessee Wildlife Resources Agency (TWRA) has been debated (Powers, L. 2003, pers. comm.). Additionally, the USFWS has been petitioned to list *G. p. gulolineatus* under the Endangered Species Act of 1973, as amended (Tawes, R. 2003, pers. comm.). Should additional distributional, biochemical, or genetic

information further demonstrate the distinctiveness of each population, additional protections may be expected at the state and federal level.

Tyto alba (barn owl)

The barn owl (state deemed in need of management) is a wide-ranging species scattered throughout North America (Tennessee Division of Natural Heritage 2003B). Although they have been recorded throughout Tennessee, they are considered an uncommon permanent resident (Eagar & Hatcher 1980). This is our most easily recognized owl, owing to its light-colored heart-shaped facial plumage. They stand approximately 18" high with a 44" wingspan. The barn owl is most commonly associated with old fields, their preferred foraging habitat, and typically nest in man-made structures or tree cavities (Tennessee Division of Natural Heritage 2003B). Small mammals make up the majority of their diet (Eagar & Hatcher 1980).

There is a 1988 record of this species from the Suggs Creek community approximately four miles northwest of the State Forest boundary on the Gladeville USGS topographic map. The barn owl probably does nest on the State Forest, and certainly must forage over its barrens and other early successional habitats.

Neotoma magister (eastern woodrat)

The eastern woodrat (state deemed in need of management/federal management concern) is a ubiquitous, charismatic mammal present over much of the State Forest (Figure 11). Woodrats, or evidence thereof, were observed in nearly every passable cave or sink examined in this study (22 sites). Additionally, Ken Oeser and Carey Frost (TCS) reported another six woodrat sightings during numerous cave mapping exercises at sites not visited by DNH.

Figure 10. *Gyrinophilus palleucus* – Tennessee Cave Salamander (courtesy of Dr. Tom Barr)

Figure 11. *Neotoma magister* – Eastern Woodrat

The species is recognized by its soft pelage, brownish-gray on their backs and white underneath. Total length can approach 17", half of which is tail. The habit of the species is to occupy caves, protected cliffs, rocky sinks, and forested talus, and to create easily recognizable nests made of dried grasses and other plant material. They liberally "decorate" their nests with fresh plant matter, cedar cuttings, and other greenery (Eagar & Hatcher 1980). Woodrats also habitually collect nuts and seeds and store them in or near the nest. They also tend to defecate in defined areas, or latrines. Decaying woodrat feces is often a food source for terrestrial cave invertebrates or their larvae. Because they typically forage outside the cave but defecate within it, they are a critical component to nutrient cycling in cave systems.

Despite their apparent abundance on the State Forest, rangewide the species is under threat. Significant declines have been witnessed in the northern part of their range (New York, New Jersey, Pennsylvania), now attributed to a parasite called the raccoon roundworm (*Balyisascaris procyonis*). The parasite can be transmitted to woodrats when raccoons leave infected feces in areas shared with woodrats. Currently the impact of this parasite on Tennessee woodrat populations is unknown, however, researchers remain concerned that epizootic will continue to push southward towards Tennessee (Henry, T.H. 2003, pers. comm.) This potential threat to Tennessee populations is a deciding factor in the species remaining listed as deemed in need of management.

Chondestes grammacus (lark sparrow)

The lark sparrow (state threatened) has been recorded from two locations near the State Forest, most recently in 1994 in an old field adjacent to the main entrance to the State Park off U.S. Highway 231 (Tennessee Division of Natural Heritage 2003B). This

approximately 6” tall sparrow is an uncommon nesting species in Tennessee, and is found most frequently in old fields with scattered shrubs and small trees, and in barrens and other early successional habitats (Eagar & Hatcher 1980). Typically they nest on the ground, sometimes using actively cultivated sites. Nests in such habitats are often lost during crop production (Eagar & Hatcher 1980).

The species is recognized by the chestnut-colored sides of the crown and cheek patches, the light line over the eye, and a black moustache-shaped mark on either side of the white throat. The State Forest potentially provides outstanding early successional breeding habitat for this species, so long as management activities in those areas do not occur during their spring nesting period.

Typhlichthys subterraneus (southern cavefish)

Tennessee’s only blind fish species, the southern cavefish (state deemed in need of management/federal management concern) has been reported from the deepest point in Cedar Forest Cave (State Forest) and also in Jackson Cave (State Park). This apparently unpigmented species is troglobitic, occurring solely in phreatic environs. Rangewide they have been found in wet caves of varying sizes, in sinks, and have even been videotaped during drinking water well inspections (Tennessee Division of Natural Heritage 2003B). Like the Tennessee cave salamander, this species can survive in perennial wet cave environments, most of which on the State Forest cannot be accessed for rare species inventory.

The southern cavefish can reach a total length of 3.5”, and feeds primarily on copepods, amphipods, and isopods (Etnier and Starnes 1993). Because of the species low fecundity, short life span, and sensitivity to chemical contaminants, the cavefish remains

listed as deemed of need of management by TWRA. Of the cave-dwelling vertebrates mentioned in this study, this species will be most directly affected by management actions that influence habitats in and near karst features that are linked to phreatic passages.

Vernal Pools

Although not a habitat based upon plant assemblages, vernal, or temporary pools are one of the more interesting habitats on the State Forest. Vernal pools can occur within natural closed depressions, as a result of road construction or earth moving, or alongside low-gradient intermittent stream channels. Even road ruts can behave as small vernal pools. Within the State Forest, the sheer abundance of large closed depressions provides the potential for numerous vernal pools. Because the State Forest contains very few perennial streams, the presence of standing water outside of storm events suggests that these habitats will be particularly critical to animals that require water during part of their life cycle.

Amphibians, in particular, benefit from these habitats. Because vernal pools dry up periodically, fish communities do not persist. The numerous salamanders, frogs, and toads that require standing water to nurture their eggs and larvae can be significantly impacted by fish predation. Having fishless bodies of water provides local amphibian populations an ideal habitat for this part of their life cycle. Table 6 lists amphibian species which have been documented from Wilson County, and can be expected on the State Forest.

Numerous other animals will utilize vernal pools seasonally. In particular, aquatic insects, including those terrestrial species that have an aquatic larval stage (e.g.

dragonflies) also benefit from fishless pools. At least two families of aquatic snails, Lymnaeidae and Physidae, prosper in vernal pools because of their remarkable fecundity and adaptations to temporary waters. The diversity of invertebrate organisms supported by these habitats provides food for numerous vertebrates, including waterfowl, wading shorebirds, and passerines. The presence of standing water- in some vernal pools even after a prolonged dry spell- also provides a necessary source of drinking water for game and nongame species alike.

Another critical function of depressional pools is their value as filters for the karst aquifer. Although a significant portion of the sinks on the State Forest are open-throated, thus retaining surface water only for a short period, closed or plugged basins will retain water for an extended time. In doing so, the vegetation, soil microbes, and other organisms can better assimilate nutrients and potential contaminants before they enter the groundwater. Because the karst terrain subsumes a majority of the precipitation that the State Forest receives, and because troglobitic organisms are generally adapted to low-nutrient conditions, the filtering capacity of depressional pools is of prime importance to the maintenance of subterranean habitats.

Karst Features

Quite possibly the greatest characteristic inherent in the State Forest is attributable to its karst topography. The forest communities, glades, barrens, rare plants, and rare animals are intimately tied to this landform. Without this foundation, much of the diversity and uniqueness of the State Forest would not exist.

Of the various karst features on the State Forest - including caves, sinks, and boulder fields- those that can be directly explored by humans are of great import. Caves in particular are remarkable, as they provide a refuge for numerous relatively large animals, specialized habitats for others, and give us a glimpse into some extremely ancient yet relatively unchanging environments.

Although several larger caves from the State Forest were published long ago (Barr 1961; Matthews 1971; Matthews 1994; Wilson 1980), numerous others were only relatively recently discovered (Oeser 2003). Through the volunteer efforts of Ken Oeser, Carey Frost, and other Nashville Grotto and TCS members, the number of known caves and sinks on the State Forest has increased dramatically over the last decade. Their research into these features in and around the State Forest continues still, typically resulting in a detailed map of each explored cave, sink, or pit.

Concurrent with these TCS investigations, the DNH documented several other accessible features that were previously unknown. Mr. Oeser and Mr. Frost subsequently have mapped the subterranean features of a number of these in detail.

Table 7 provides basic information for accessible subterranean features known from the State Forest (and some that abut State Forest property and may extend beneath it). The maximum vertical and horizontal extent, if known, is indicated or estimated. The presence of rare species is noted, along with the coordinates of each site in degrees, minutes, seconds format. Greater detail is provided in the accompanying GIS product, and any rare species information is included in the rare species occurrence printouts found in the Appendix.

Prior to initiation of DNH surveys, 23 accessible caves and sinkholes were known from the State Forest (Oeser 2003). The DNH recorded an additional 20 passable caves and sinks, many of which have subsequently been investigated by the TCS (Oeser 2003). As noted in Table 7, caves and sinks newly discovered by the DNH are indicated under "Source," and DNH will appear as the first or only entry.

Far more abundant on the State Forest than human-accessible caves or sinks are a plethora of other sinks, depressions, crevices, and limestone canyons. Their presence adds a remarkable character to the landscape of the property. Although numerous other such features are present on the State Forest, the DNH recorded and mapped the surface locations of over 350 sinks of various shapes, sizes, and drainage areas. Summary statistics for each type of landform are shown in Table 8, and details are shown in the GIS attribute file.

Cultural Features

DNH staff recorded nineteen historical structures consisting of old foundations, walls, and cemeteries. This combined with the previous data collected by the Division of Archeology[17] further indicates that the vegetation on the State Forest has been greatly influenced by past land practices. Virtually all of the remaining structures consist of limestone either in the form of now low walls or past foundations. The most intact stone wall observed by DNH is located approximately 275 yards from the Sam Drennan house as recorded by Division of Archeology. Only one wooden structure was observed by DNH staff.[18] TDF staff indicated that just after government acquisition of the land in the

[17] All locational data provided to TDF in ArcView shape file format.
[18] This apparent barn is located at the "Charlie Night House" as determined by Archeology just off of the Matt Knight Trail on the northeast section of the State Forest.

1930s, structures were deliberately razed to prevent squatters or local residents from continually inquiring about renting the homes.

Documented home sites by DNH often corresponded with sites located by Division of Archeology with some minor mapping discrepancies likely due to greater precision afforded from GPS units. However, four structures and one cemetery identified by DNH were not included in Division of Archeology information provided by TDF. It is possible that Division of Archeology has since obtained information, but it may be beneficial for archeologists to visit these sites.[19]

Management Recommendations

The following recommendations provide TDF with information as to how best manage for ecologically significant features on the State Forest[20]. Some may be site specific while others are more general in nature, but all are meant to aid in the conservation of natural resources. These recommendations are not necessarily for best timber management (although there is likely some overlap), but take into account all features, especially rare species or unique habitats. The fact that portions of the State Forest are designated as State Natural Areas will need to be considered when implementing management, but DNH feels that these recommendations should apply to the designated portions as well.

The accompanying GIS layers will aid land managers in identifying areas where management is needed (e.g. exotic species infestations, barrens restoration sites). All points in the layer, including rare species occurrences, will be beneficial in decision

[19] The cemetery is located north of Simmons Bluff Road on the southeast section of the Forest and has a unique identifier in the GIS file of MANMADE03. The structures are labeled in the GIS file as MANMADE04, MANMADE12, MANMADE13, and MANMADE17.
[20] Table 4 lists predicted management effects on rare plants.

making, but there are a few types of GIS points which TDF may find most useful. The type "RESTORE" indicates sites where the habitat has been altered (e.g. old fields, past pine plantations), and areas labeled "BARRENS" contain some barrens which would benefit from management. Points labeled "EXOTIC" are areas where there are exotic species infestations while those labeled "DEGRADE" primarily indicate areas where recent trash dumping has occurred.

Limiting Vehicle Access

TDF has used barriers of boulders or other material to prevent vehicles from accessing certain portions of the State Forest. The boulders such as those at the far west end of Cedar Forest Road assist in reducing traffic and likely discourage some dumping. However, numerous trails have no type of gate or barrier to prevent vehicle access[21] and many of these trails lead to pristine glades containing rare plants and sensitive habitats. Fortunately many of the non-gated areas have not experienced a great amount of erosion or degradation from off highway vehicles (OHVs), but if left unchecked these areas will undoubtedly be subjected to further OHV use and trash dumping.

The north/south section of Arnold Trail (located on the southeast side of the State Forest) is an example of unlimited vehicle access. This trail contains numerous deep mud holes and portions of the trail are excessively wide due to OHV use. When DNH staff visited the trail during the 2003 field investigations, it was not uncommon to find vehicles stuck in the mud and one had been abandoned and set afire. Arnold Trail is in such poor condition that even after closure, TDF may wish to grade it and perhaps spread some gravel to prevent even further erosion.

[21] Some examples include Gannon, Mullberry, Doc Jones, Thompson, Arnold, Robinson, James Jordon, Harris, and Foutch Trails as well as Burnt House Road, and the former motor cross trail.

There are different methods of limiting vehicle access on the State Forest. Blocking the roads with gates as was done at the entrance of Sue Warren Trail (one of the few trails which is gated) would likely work since locked gates allow TDF staff to access the areas with vehicles when needed. The large boulders used at some roads are also effective, but this limits access from land managers, researchers, or emergency vehicles.

Limestone glades which are not buffered from the roadside by trees or shrubs almost always are highly disturbed (e.g. along Whippoorwill Road). Many of these large areas contain past and present dump sites, have virtually no top soil, and are continually impacted by vehicles. Since there is lengthy frontage between these areas and the adjacent roadside, gates would be ineffective.

Past attempts to protect these areas include the creation of linear berms between the roadside and the glade as found along Cedar Forest Road west of U.S. Highway 231. Since the disturbance resulting from scraping of gravel is virtually irreparable, and the berms can be driven over by all terrain vehicles (ATVs), such measures are not recommended. Barriers of brush and downed trees, as found along Cedar Forest Road just west Richmond Shop Road, seem to prevent vehicle access without affecting the integrity of the glade. Brush barriers also provide refuge for numerous passerine birds, some of which are uncommon statewide. Protection of the roadside glades which have already been degraded is a lower priority since they are badly eroded and the few rare glade plants which do occur in these sites are often on the margins which are less frequently impacted.

Gating or additional signage will diminish the amount of vehicle traffic, but realistically there is no way to completely eliminate all illegal vehicle use on the State

Forest. ATVs can simply drive through the woods and around obstacles such as boulders, gates, or felled trees. Therefore, TDF staff may wish to regularly patrol problem areas in order to be a visual presence and issue citations as needed. Although the goal should be the closure of all trails to vehicles, the priority of gating trails should be placed at those areas which currently do not have excessive damage such as Harris Trail, the far north end of Proctor Trail (where the gate has been destroyed), or the trail heads just north of Simmons Bluff Road.

Dumping of Trash

Piles of trash are on many glades on the State Forest and more recent dumping along roadsides continues to be a problem. TDF staff have been diligent in attempting to locate and issue citations to offenders, and their efforts likely assist in reducing the number of dump sites on the State Forest.

The presence of trash piles on the State Forest is unsightly for visitors and may actually encourage others to dump which would further the problem. Some of the more recent sites of illegal dumping can be identified through the GIS[22] layer, and it is recommended that trash be removed from these areas. TDF staff may be able to remove much of the trash, and perhaps can utilize persons conducting community service or volunteers on special occasions such as Earth Day. A program of trash removal, prosecution of violators, and additional signage throughout the State Forest would undoubtedly reduce the number of offenses.

Barrens Maintenance/Restoration

Although the barrens habitat contained virtually no rare plant species, their maintenance provides multiple stages of succession and grassland habitat. Probably the

[22] Such GIS points are labeled DEGRADE.

greatest nongame wildlife value ascribed to these habitats is that they support numerous native bird species, including granivorous, insectivorous, and carnivorous species. The native grasses present in early successional habitats provide both food and complex nesting habitats for several species, harbor a wide variety of flying insects, and supply cover for rodents. Thus, despite the apparent lack of rare plants and animals, these habitats are still important to the overall species diversity of the State Forest.

Barrens were mapped and documented in the GIS table, and some of these sites require management because of woody plant colonization, primarily by eastern red cedar. Thus, in order to maintain these open or barren areas in early successional stages, tree removal will be necessary. Possible methods of tree removal or combinations thereof include cutting, mowing, and use of prescribed fire.

Most of the sites identified have larger trees which could be removed prior to mowing or burning. However, a mosaic of grassland interspersed with open-grown trees may be desired and mowing and prescribed burning could be conducted simply to reduce sapling density.

When possible, existing trails should be used as fire lines so as not to encourage additional OHV use on the State Forest. Unless absolutely necessary, plow lines should be avoided in order to minimize soil disturbance and erosion. Depending upon exact weather conditions, prescribed fires could be conducted any time between fall and early spring.

Since mowing is not dependent on precise weather conditions or large crews, it may prove an easy alternative to burning. Mowing should be conducted in the dormant season of late fall to very early spring to allow for herbaceous plants to set seed. When a

specific barren is targeted for mowing, the exact entrance to the barren should be considered to avoid encouraging OHV use along the mowed path.

If TDF or DNH decide to intensively manage specific sites, prescribed fires should be varied in order to avoid harmful effects on fauna including moths and other insects. The standard prescription applied to homogeneous grassland tracts in eastern North Carolina requires that approximately 2/3 of the burn unit remain out of rotation on successive burns, that these "refugia" are never wholly burned in a single event, and that at least three growing seasons lapse between burns (Hall, S. 2003, pers. comm.). This ensures that populations of short-lived, specialized invertebrates- especially insects and land snails- are not unnecessarily harmed by management activities. Because insect diversity is poorly understood except in rare circumstances, it is far better to err on the side of caution when actively managing these areas. Other means for achieving management objectives may be available when fire is inappropriate, including chemical, biological, and mechanical techniques.

Roadside Management Along Cedar Forest Road

As previously noted, Cedar Forest Road west of U.S. Highway 231 provides a great representation of rare plant populations, and glade and barren habitats, and this easily accessible area of unique features should be maintained. Without management the roadside would succeed to a shrubby and ultimately tree-dominated habitat. The easiest and likely most cost-effective management would be regular mowing. As in the barrens habitat, any mowing should be conducted during the dormant season after all herbaceous plants have set seed. If desired, mowing other roadsides should also be done in the dormant season.

Eastern red cedar, which does not re-sprout when cut, is the woody species invading the barrens habitat along the roadside. However, many of the other roadside areas not dominated by little bluestem grass support growth of hardwood species such as redbud, sumac, and the exotic tree-of-heaven. Regular observations should be made in these portions along Cedar Forest Road, and if the hardwood species show vigorous re-sprouting after mowing, additional control methods may be needed.

Such methods to control hardwood sprouting could include the use of herbicide following dormant season mowing. A quick post-mowing spot application would effectively treat the hardwood saplings and likely not affect the desired herbaceous plants. Since it has yet to be determined if and where such treatment is needed, no specific recommendations are provided at this time.

Management of Former Pine Plantations

Eight former pine plantations (and one old field to be treated as such for management recommendations) were identified during field work, two of which occur on the Cedars of Lebanon Designated State Natural Area.[23] These areas could be managed/restored in a variety of ways including burning for grassland habitat, replanting in pines, or planting in hardwoods. Unless TDF wishes to place these areas back into pine production, the DNH recommends that they be allowed to naturally succeed and predicts that the areas of deeper soils will eventually mature to hardwood forest. Such a natural succession to hardwoods would still allow for commercial timber management if desired. If TDF desires to reforest the sites with hardwoods, species which naturally occur on the State Forest (e.g. various oaks and hickories) should be used.

[23] A review of the GIS file type RESTORE will indicate restoration areas including former pine plantations.

Since the Cedars of Lebanon Designated State Natural Area contains areas where pines have been harvested in the past, the DNH encourages TDF to consult with the TDEC Natural Areas Program if management other than natural succession is desired. Allowing for natural regeneration provides a variety of benefits to certain vertebrate animal species as indicated above regarding early successional habitats. Some portions of the Natural Area contain saplings of loblolly pine and since this species is not native to the Central Basin of Tennessee, and could begin to invade barrens or margins of glades, it is recommended that it be removed.

Currently the past pine plantations do not contain large infestations of exotic plant species. However, due to recent disturbances and the presence of "Severe Threat" species on the State Forest (e.g. tree-of-heaven, sericea lespedeza, Chinese privet, bush honeysuckle, Japanese honeysuckle, and Nepalese grass), these areas should be regularly inspected to ensure that these species are not invading, and if they are, treatment should be implemented.

Land Management Near Karst Features

Certain traditional forestry practices on the State Forest must be tempered with the knowledge that many karst features are particularly sensitive habitats. Open-throated sinks and depressions are most susceptible to interference by mechanical, chemical, and pyric management activities, owing to the short retention time associated with the movement of water through them. The longer retention times associated with closed depressions normally allow for greater biological assimilation of extraneous materials, though certain management tools are best not used in these habitats as well. Generally, a manager's primary concern in karst areas should focus on the potential for surface waters

to transport excessive nutrients or contaminants into the phreatic systems beneath the State Forest.

Fire is an obvious and valuable tool for achieving certain management objectives. In karst areas, however, the accumulation and transport of potash into sinks can markedly raise the pH of subterranean waters (increasing alkalinity), at least for a brief period. Although limestone aquifers are relatively well buffered, the allochthonous materials primarily received by these systems are normally acidic (e.g. tannic acid from decaying oak leaves, etc.). Although periodic fires may not be problematic, excessive, repetitive prescribed fires near sinkholes should be avoided. In general, open-throated karst features should be buffered from prescribed fires by a distance sufficient to permit potash-laden runoff to be absorbed by the soil prior to reaching an inflow point.

Likewise, large-scale or broadcast chemical management is ill-advised near karst features, particularly for open-throated sites. Prudent designation of buffers will prevent the unnecessary intrusion of foreign and particularly hazardous chemicals that may directly and negatively impact cave-dwelling organisms, or that may indirectly harm them by altering their food supply or other habitat features.

Although mechanical management and harvest can be undertaken in karst areas, care should be exercised to limit the soil disturbance in a given area. Many of the sinks on the State Forest are actively developing, and imprudent use of heavy equipment can accelerate this process to an unknown end. Also, an influx of sediment into perennial phreatic systems can negatively impact rare or sensitive cave species that have evolved in a stable and nutrient-poor environment. In general, fire lines, haul roads, and staging areas should be kept away from karst depressions. Harvest of particularly large trees

from sinks may also not be advisable because of the development of extensive root systems integrated into the karst.

Vernal Pools

Vernal pools are recognized as one of the most abundant and important habitats on portions of the State Forest. The dependence of numerous animals on these habitats for feeding and reproduction cannot be underestimated. Those naturally occurring temporary pools are generally associated with closed-throated depressions, and to a lesser degree with certain glade habitats. Management of these areas should respect the same prescriptions outlined for sinks, above, primarily to avoid impacts to breeding amphibians during the wetter months.

Other vernal pools are clearly manmade, either as an artifact or direct consequence of earth moving, or by the illicit use of OHVs in erodable areas. Amphibians are often attracted to these areas because they receive far more direct sunlight than forested pools, allowing for ectotherms to more easily maintain suitable metabolic rates during cool periods. Waters warmed by the sun also permit more rapid development of amphibian larvae, shortening the period during which they are dependent on standing water.

Though various organisms frequently use such habitats on the State Forest, and the gating of roads will help protect existing pools, they should not necessarily be a priority for active management. Over time many such pools will silt in and lose their ability to store water even for brief periods. However, naturally occurring vernal pools associated with open glades and barrens should provide adequate sites that serve the same ecological function.

Exotic Plant Management

As noted previously, invasive exotic plants pose a serious threat to native species and communities on the State Forest. If left unmanaged, they could threaten plant and animal biodiversity, reduce tree regeneration, usurp forest productivity, and hinder forest-use activities (Miller 2003). Thirty exotic plant species were documented on the State Forest[24], and of these, six species are listed as a "Severe Threat", including tree-of-heaven, sericea lespedeza, Chinese privet, Japanese privet, bush honeysuckle and Nepalese grass (Table 9). Because these species tend to spread aggressively and displace native vegetation, they should be considered a priority for management, especially those exotic infestations such as privet and bush honeysuckle, which are found in small isolated areas on the State Forest[25]. Eradicating these small infestations as soon as possible is critical to preventing their spread. Tree-of-heaven, although not widespread at Cedars, is locally abundant on some areas of the State Forest and is perhaps one of the more serious threats to native species and communities. Targeting the smaller, outlying populations, and working towards the denser areas of infestation will help contain its spread.

In the following sections, general management techniques for controlling exotic plants are discussed followed by detailed management prescriptions for those exotics species found on the State Forest which are listed as a "Severe Threat." These management techniques are intended to provide TDF staff with general information about the tools and strategies available for controlling invasive exotic plants. Typically, successful weed control will require the use of several methods. All available control options should be considered: manual, mechanical, grazing, prescribed fire, herbicides,

[24] Exotic infestations, which were mapped and documented, are labeled EXOTIC in the GIS coverage.
[25] Refer to Frequency in Table 1 as well as to the GIS layer for an idea of the extent of an exotic infestation.

and other, more novel techniques (Table 9). Each has advantages and disadvantages in terms of its effects against the target weed(s), impacts to non-target plants and animals, risks to human health and safety, and costs. When selecting control methods, keep in mind that the ultimate purpose of the work is not simply to eliminate the exotics, but rather to preserve native species and communities.

Manual and mechanical techniques such as pulling, grubbing, cutting, mowing, girdling, and tilling may be used to control some invasive plants, particularly if the population is relatively small. Annuals and tap-rooted plants are particularly susceptible to control by hand pulling or pulling using tools. This method is not as effective, however, against many perennial weeds with deep underground stems and roots. Mowing and cutting are often used as primary treatments to remove aboveground biomass, to reduce seed production and to restrict weed growth, especially in annuals cut before they flower and set seed (Tu, Hurd, and Randall 2001). Manual and mechanical treatments must typically be administered several times to prevent the weed from re-establishing. While these techniques are generally labor and time intensive, they are extremely specific, minimizing damage to desirable plants and animals.

Prescribed fire can also be an effective and efficient tool for controlling the invasion of some exotic plants. Fire not only reduces the abundance of many woody and non-native plants, but it also enriches the soil, lengthens the growing season, and stimulates the germination of some native plants.

The most effective fires for controlling invasive plants are typically those administered at the young seedling/sapling stage or just before flower or seed set. In some cases, prescribed burns can unexpectedly promote an invasive species, such as

when their seeds are adapted to fire. In these situations the burn prescription must be modified or other management actions taken to control the invasive plant. Spot-burning invasive weeds with a propane torch can be cheaper and easier than conducting a prescribed burn, but is only effective when the infestation is small.

Grazing is yet another method that can help reduce vigor of palatable invasive plants. The Nature Conservancy has used goats as part of an integrated approach to control privet on some of their Nature Preserves in Tennessee and has found this method to work well. The goats however, must be able to reach and destroy adult privet plants (Batcher 2000).

Extensive infestations may require more aggressive methods of control such as the selective application of herbicides to target exotic plants. In general, for work in natural areas, it is best to select herbicides that are effective against the weed, not likely to drift, leach to groundwater or wash into streams, that are nontoxic to people and other organisms, and are not persistent in the environment (Tu, Hurd, and Randall 2001). The selective methods described in this section are directed foliar application, cut-treat, stem injection and basal bark treatment.

Foliar Application

Foliar applications involve applying herbicide directly to the leaves and stems of target plants. An adjuvant or surfactant is often needed to enable the herbicide to penetrate the plant cuticle. There are several types of foliar application tools available, including spot applicators, wick applicators, and boom applicators. Foliar applications are usually most effective when applied from midsummer to late fall, although spring and winter applications can be useful for specific plants and situations (Miller 2003).

Cut-Treat

This method is often used on woody species that typically re-sprout after being cut. Cut-treat involves applying herbicide to the entire inner bark (cambium) of freshly cut stumps within 5-10 minutes after the trunk or stem is cut. Herbicide can be applied to cut stumps in many ways, including spray and squirt bottles, backpack sprayer, wick, or even paint brushes. It allows for a great deal of control over the site of herbicide application, and consequently, has a low probability of impacting non-target species or contaminating the environment. It also requires only a small amount of herbicide to be effective. The most effective time of the year for the cut-treat method is summer through late winter (as long as the ground is not frozen). Heavy spring sap flow can wash herbicide from cuts, making this an ineffective period to use this method.

Stem Injection

Stem injection (including hack-and-squirt) is a selective method of controlling larger trees and shrubs with minimum damage to non-target plants. It requires cuplike downward incisions spaced around the trunk with a measured amount of herbicide applied into each of the incisions. Special tree injectors (such as the EZ-Ject Lance) are available to perform this procedure, or a sharp knife, saw, ax, or power drill along with a squirt bottle of herbicide can be used in sequence to perform the hack-and-squirt method.

Basal Bark

Basal bark treatments are effective in controlling woody stems less than about 6 inches in diameter, before bark becomes thick and corky. This method involves applying a 6 to 12 inch band of an herbicide-oil mixture around the circumference of the trunk of the target plant, approximately one foot above ground. The herbicide can be applied with

a backpack sprayer or a wick applicator. Applications are generally done in late winter and early spring, when leaves do not hinder spraying the trunk.

The following are management prescriptions for those exotic plants found on Cedars of Lebanon State Forest which are listed as a "Severe Threat." These prescriptions have been assembled from various weed control manuals, published research results and web sites cited at the back of this document.

Ailanthus altissima (tree-of-heaven)

A variety of control methods have proven effective in controlling the spread of tree-of-heaven. Young seedlings can be effectively controlled by hand pulling. Mechanical control such as cutting with a power or manual saw can serve as an initial control measure to prevent seed production. However, success will most likely require either selective herbicide application or repeated cuttings for re-sprouts (Hoshovsky 1988).

Herbicidal controls including foliar spray, cut-treat, stem injection, and basal bark application have proven effective in controlling more mature tree-of-heaven. The foliar spray method should only be considered for large thickets of ailanthus seedlings where risk to non-target plants is minimal. Apply a 2% solution of either glyphosate (brand names include: Roundup, Rodeo, Accord) and water or triclopyr (brand names include: Garlon, Pathfinder) and water, plus a non-ionic surfactant, to thoroughly wet all leaves (Southeast Exotic Pest Plant Council 1997). Glyphosate is a non-selective systemic herbicide that may kill non-target plants if accidentally sprayed. Triclopyr is a selective herbicide for broadleaf species and may be used in areas where desirable grasses are growing without non-target damage.

The cut-treat and stem injection methods should be considered when treating large individual trees where the presence of desirable species precludes foliar application. In each case, apply a 50% solution of either glyphosate and water or triclopyr and water to the freshly cut stump or stem. If using the basal bark method, apply a mixture of 25% triclopyr and 75% horticultural oil to the basal parts of the tree. Thorough wetting is necessary for good control.

Lespedeza cuneata (sericea lespedeza)

At present, the best control of lespedeza combines both mechanical and chemical treatments. Hand pulling is impractical due to its extensive perennial root system, but mowing plants in the bud stage for two or three consecutive years, may reduce vigor of lespedeza stands and control further spread. Plants should be cut before seeds mature (Stevens 2002). Mowing followed by a herbicide application is likely the most effective option for the successful control of lespedeza.

Herbicidal controls have proven effective as long as the plants are actively growing. Foliar applications of glyphosate, triclopyr and metsulfuron (tradename Escort), plus a non-ionic surfactant, are effective in controlling lespedeza. Apply a 2% solution of glyphosate or triclopyr mixed with water. Metsulfuron should be applied at a rate of 0.3g/gallon of water (Southeast Exotic Pest Plant Council 1997).

Ligustrum sinense (Chinese privet)

Manual and mechanical treatments of privet[26] including hand pulling, mowing and cutting are appropriate methods for controlling young seedlings and small initial populations or for use in environmentally sensitive areas where herbicide cannot be used.

[26] Not to be confused with the native glade privet (*Forestiera ligustrina*)

As is the case with many invasives, mowing and cutting will control the spread of privet but will not eradicate it.

The use of goats to graze privet has also been documented as an effective method for controlling privet by the Tennessee Chapter of The Nature Conservancy. This method works best in young privet stands that the goats can successfully reach and destroy.

The following chemical treatments have also proven effective in controlling privet: foliar spray, cut-treat and basal bark (Southeast Exotic Pest Plant Council 1997). Because privet was only documented on one small site in the State Forest[27], immediate eradication of this population should be a top priority for TDF staff. If left untreated, this infestation will surely spread to other areas and could severely impact native vegetation, changing the integrity of the natural area. It is suggested that the cut-treat method be used to treat this population of privet, applying a 25% solution of glyphosate or triclopyr and water to the cut stump to minimize risk to non-target species in the area.

Lonicera japonica (Japanese honeysuckle)

The most effective control of Japanese honeysuckle combines prescribed fire and herbicides. Late autumn or winter burns can be used to reduce Japanese honeysuckle biomass when most native species are dormant. Resprouts can then be treated with a foliar application of herbicide about a month after they emerge. Apply a 1.5% solution of glyphosate. If using herbicide as the sole method for controlling Japanese honeysuckle, applying herbicide shortly after the first killing frost, and before the first hard frost, appears to be the most effective treatment (Nuzzo 1997).

[27] This population is labeled "Exotic 01" in the GIS layer and is in the vicinity of two leafy prairie clover occurrences, a federally endangered plant.

Lonicera maackii (bush honeysuckle)

Manual and mechanical methods proven effective in controlling juvenile plants or small initial populations respectively include pulling, grubbing and cutting. Mechanical management typically requires repeated treatments for a period of three to five years to control the respouts. Repeated annual prescribed burns during the growing season have also been shown to top-kill shrubs and inhibit new shoot production. Because exotic bush honeysuckle readily resprouts, it may be necessary to re-burn every year or every other year for several years.

Many land managers report that treatment with herbicides is necessary to control bush honeysuckle. Water soluble formulations of glyphosate or triclopyr can be used as foliar sprays or cut-stump treatments. Foliar applications should take place late in the growing season, and cut-stump applications from late summer through the dormant season (Batcher and Stiles 2000). Use a 2% solution of glyphosate or triclopyr for foliar applications and a 20-25% solution for cut-stump treatments. Like privet, bush honeysuckle was only documented at one small site on Cedars, along the Sue Warren Trail[28]. Consequently, immediate eradication of the infestation should be a priority. If the bush honeysuckle is controlled at this initial stage, TDF will undoubtedly benefit from the time, energy and cost savings associated with early detection and management. To ignore the infestation would be opening the door for this exotic species to outcompete and displace native species. It is recommended that the cut-treat method be used to treat this population of bush honeysuckle, applying a 25% solution of glyphosate or triclopyr and water to the cut stump.

[28] This population is labeled EXOTIC25 in the GIS layer and also occurs in the vicinity of a leafy prairie clover occurrence, and should be targeted soon.

Microstegium vimineum (Nepalese grass)

For small infestations, manual or mechanical techniques may be the best method for controlling Nepalese grass, since it is a shallowly-rooted annual. Hand pulling, however, is extremely labor-intensive, and will need to be repeated for at least seven years to exhaust the seed bank. Mowing may be an effective technique for controlling the spread if carried out in late summer, when the plants are in peak bloom but before seed is produced.

For larger infestations, systemic herbicides such as glyphosate or imazameth (tradename Plateau) or grass-specific herbicides like sethoxydim (tradename Vantage or Post) may be effective (Tu 2001). Of these, imazameth (applied at a rate of 6 ounces per acre) seems to be the herbicide of choice for many land managers since it kills microstegium but allows the development of native sedges, legumes, and ragweeds.

Conclusion

The ecological inventory at Cedars of Lebanon State Forest is an excellent example of the primary role for which Heritage programs were originally conceived. The opportunity to generate and synthesize field data from different scientific disciplines over such a remarkable natural resource has been a great benefit to DNH. The burgeoning partnership with TDF compliments DNH's mission well, and future opportunities are welcomed.

Beyond a doubt, creation of the Forest through private land purchases in the 1930s- and their subsequent transfer to the TDF in the 1950s- was a pivotal and prudent investment. Certainly the significance of its acquisition could not have been fully appreciated at the time. The State Forest provides an excellent example of the plant and

animal communities associated with limestone cedar glades and barrens, and is a key refuge and preserve for regionally and globally rare and endemic plant species. Two federally listed plant species and numerous state-listed plant species and their habitats are protected within the State Forest. Likewise, at least two state-listed animals reside on the State Forest, and its myriad of habitats provide refuge for an incalculable diversity of invertebrates.

The often stark karst topography provides a remarkable contrast to its rolling hills and deep, mature forests- quite diverse for an area with such limited topographic relief. The subterranean environs of the State Forest- though often tedious to access or navigate- add a level of complexity to the ecology that may be lost to the casual observer. To fully explore the attributes of the karst systems of the State Forest, TDF may wish to actively pursue partnerships with TCS and other conscientious cave explorers to acquire better knowledge of this resource.

Although additional surveys will yield more information, this report affords TDF a better understanding of the State Forest's biota. DNH encourages TDF to continue the promotion of novel ecological research, particularly in those disciplines not fully represented in the current study. With the numerous fascinating habitats contained on the property, and with no shortage of academic institutions in the area, Cedars of Lebanon is a fitting place for students and researchers alike. Formal arrangements with area universities and researchers would not only better TDF's understanding of its land base, but would provide the academic community greater insight into the multiple roles TDF has as steward of Tennessee's state forests. Clearly these mutual goals are in the public interest.

In addition to the value of the Forest for timber production, academic research, and as a refuge for numerous rare plants and animals, it is most certainly a place of beauty and serenity in a region prone to rapid development and loss of open space. This benefit should never be underestimated, as Middle Tennessee residents seek places to safely enjoy outdoor recreation. TDF has a challenge to find the tools and means to balance appropriate public access with the other foci that drive management practices in this area. The DNH hopes that the management recommendations will compliment this process, and help preserve the many values of the State Forest for future generations.

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Table 1. 2003 Documented Flora of Cedars of Lebanon State Forest

Frequency of Occurrence Definitions

Very Rare – A single locality, few individuals
Rare – One or two localities, generally small populations
Scarce – Several localities or scattered small populations
Infrequent – Scattered localities throughout
Occasional – Well distributed but no where abundant
Frequent – Generally encountered
Common – Characteristic and dominant

Scientific Name	**Habitat(s)**	**Frequency**	**Ex**[29]	**Rec**	**Coll**
Acalypha gracilens	trails and glade margins	occasional		x	x
Acer negundo	alluvial woods	infrequent		x	x
Acer saccharum	dry-mesic forests	infrequent			
Acer saccharum ssp. nigrum	oak-hickory forest	infrequent			x
Achillea millefolium	disturbed roadside	infrequent	x		
Aclepias tuberosa	open trailsides and waste places	scarce			
Aesculus glabra	mesic-dry cedar/hardwood forest	infrequent			
Agalinis gattingeri	open glades/barrens	scarce		x	x
Agalinis tenuifolia var. parviflora	open disturbed glades	occasional			
Agrimonia rostellata	sub-mesic mixed hardwood/cedar woods	occasional		x	x
Ailanthus altissima	successional woodlands, roadsides	infrequent	x		
Allium cernuum	open disturbed glades	infrequent			
Ambrosia artemisiifolia	disturbed places	frequent			
Ambrosia bidentata	old roadsides	infrequent		x	x
Ambrosia trifida	roadsides, barrens	frequent			
Amphiachyris dracunculoides	roadsides/glades/ruderal areas	infrequent		x	x
Anemonella thalictroides	dry-mesic forests, glade margins	frequent			
Antennaria plantaginifolia	barrens, dry openings	infrequent			
Apocynum cannabinum	dry roadsides	scarce			
Aquilegia canadensis	dry-mesic cedar/hardwood forest	occasional			
Arabis hirsuta	glades and woods	rare			x
Aralia spinosa	waste places, disturbed woods	scarce			
Arisaema dracontium	mesic cedar/hardwoods	occasional		x	x
Arisaema triphyllum	mesic cedar/hardwoods	occasional			
Aristida longespica	glade margins, barrens	occasional			x
Aristida oligantha	glade margins, barrens	infrequent			x
Artemsia annua	waste places	rare	x		
Arundinaria gigantea	alluvial successional forests	scarce		x	x
Ascelpias tuberosa	roadsides, barrens	infrequent			
Asclepias verticillata	barrens, glade periphery	infrequent			
Asclepias viridis	open barrens	occasional			
Asimina triloba	mesic forest	rare			
Asplenium platyneuron	sinkholes, karst forests	infrequent			
Asplenium rhizophyllum	moist limestone ledges, sinks	infrequent			
Aster ontarionis	dry oak cedar forest	scarce		x	x
Aster paludosus var. hemisphericus	open barrens and galde margins	occasional			

[29] Ex – Exotic plant; Rec – County record; Coll – Collection made

Scientific Name	Habitat(s)	Frequency	Ex[29]	Rec	Coll
Aster pilosus var. priceae	open glades, barren and roadsides	frequent		x	x
Aster shortii	dry cedar forests and glade margins	frequent			x
Astragalus tennesseensis	dry roadsides, glade margins	occasional			
Astranthium integrifolium	glade margins	occasional			
Berchemia scandens	dry-mesic cedar/hardwood forest	scarce			
Bidens bipinnata	moist alluvial flats, mesic woods	frequent		x	x
Bidens polylepis	disturbed grassland/barrens	infrequent			x
Blephelia ciliata	dry woods	occasional			
Botrychium virginianum	mesic cedar/hardwoods	scarce			
Bouteloua curtipendula	open glade margins	infrequent			
Brachylectrum erectum	mesic-dry woods	occasional		x	x
Bromus japonicus	open disturbed glades and roadsides	occasional	x		x
Bupleureum rotundifolium	dry roadsides, disturbed glades	infrequent	x		
Cardamine douglassii	mesic-dry hardwood forest	rare		x	x
Cardamine hirsuta	dry-mesic cedar/hardwood forest	occasional			
Carduus nutans	dry roadsides, disturbed glades	frequent	x		
Carex caroliniana	dry woods	scarce			x
Carex cherokeensis	open clear cut	rare			x
Carex crawei	glade with ephermeral drainage/wash	rare			x
Carex frankii	dry trailside glade	scarce			x
Carex gracilescens	glades, barrens, dry-mesic forest	occasional		x	x
Carex retroflexa	dry oak hickory woods	scarce		x	x
Carya ovalis	oak-hickory forest	occasional			x
Carya ovata var. australis	dry-mesic cedar/hardwood forest	frequent			
Ceanothus americana	dry mowed roadsides	rare		x	x
Celtis occidentalis	forests, edges of cedar glades	occasional			
Cercis canadensis	open glades and successional forest	frequent			
Chaerophyllum tainturieri	successional forests and woodlands, ruderal	frequent			
Chamaecrista fasiculata	open barrens, waste places	occasional			
Chasmanthium latifolium	mesic cedar/hardwoods	infrequent			
Cheilanthes lanosa	glade margins, successional glades	occasional			
Chimaphila maculata	mixed hardwood/pine (planted) forest	very rare		x	x
Cichorium intybus	roadsides	infrequent	x		
Circium discolor	glade margins	occasional			
Claytonia virginica	mesic-dry cedar/hardwood forest	occasional			
Clematis catesbyana	mesic cedar/hardwoods	occasional			x
Clematis viorna	succesional woods	occasional		x	x
Clematis virginiana (imm/veg. catesbyana?)	succesional forests, roadsides	frequent			
Commelina erecta	mesic woods	infrequent			
Conoclinium coelestinum	mesic woods/waste places	occasional			
Conopholis americana	dry-mesic cedar/hardwood forest	infrequent			
Cornus drummondii	mesic-dry woodlands	infrequent			
Cornus florida	dry-mesic hardwood forest	occasional			
Coronilla varia	pine clear cut	scarce	x		
Corydalis flavula	mesic-dry karst cedar/hardwood forests	infrequent			
Croton capitatus	open glades/barrens	occasional			
Croton monanthogynous	glades and disturbed roadsides	frequent			
Cryptotaenia canadensis	mixed hardwood/cedar forest	very rare		x	
Cuphea viscosissima	wet swale glades	infrequent			
Cuscuta pentagona	open glade (parasitic on Ruellia)	very rare			
Cynoglossum virginianum	open woods	infrequent			
Cyperus acuminatus	wet open glades	infrequent		x	x

Scientific Name	Habitat(s)	Frequency	Ex[29]	Rec	Coll
Cyperus squarrosus	wet open glades, disturbed	infrequent			x
Cystopteris sp.	karst forests, woodlands, and sinks	occasional			
Dactylis glomerata	dry roadsides	occasional	x	x	
Dalea candida	dry mowed roadsides	rare			x
Dalea foliosa	ephemeral gladey washes	scarce			x
Dalea gattingeri	limestone cedar glades	common			
Danthonia spicata	dry woods and glades	scarce			x
Daucus carota	glades, roadsides, waste places	occasional	x	x	x
Delphinium carolinianum spp. calciphilum	open glade margins	frequent			
Delphinium tricorne	mesic-dry cedar/hardwood forest	very rare		x	x
Dentaria lacinata	dry-mesic hardwood forest	frequent			
Desmodium glabellum	dry upland woods	rare		x	x
Desmodium nudiflorum	mixed hardwood forest	infrequent		x	x
Desmodium rotundifolium	dry barrrens	occasional		x	
Diarrhena americana	rich limestone woods	frequent			x
Dicanthelium acuminatum var. fasciculatum	disturbed glades, barrens	infrequent		x	x
Dicanthelium boscii	trailside in woods	infrequent			
Dicanthelium clandestinum	alluvial woods along Hurricane Cr.	infrequent			x
Dicanthelium depauperatum	open cedar grasslands	occasional			x
Dicanthelium dichotomum (var. annulum?)	open barrens	infrequent		x	x
Dicanthelium laxiflorum	cedar/hardwood forest	occasional			
Diodia teres	open glades/barrens	occasional		x	
Dioscorea villosa	dry-mesic cedar/hardwood forest	infrequent		x	x
Diospyros virginiana	oak-hickory forest	rare			
Diplazium pycnocarpon	mesic sinkhole	very rare		x	x
Dodecatheon media	dry woods, margins of glades and barrens	occasional			
Echinacea tennesseensis	glade and barren margins	rare			
Echinocloa crus-galli	disturbed roadsides	rare			x
Eclipta prostrata	disturbed glades	rare	x	x	x
Eleocharis bifida	wet gladey washes, gladey swales	frequent			
Elymus hysterix	blue ash/cedar woodland	rare			
Elymus villosus	dry trailsides, dry woods	infrequent			
Erigeron pulchellus	oak forest	very rare		x	x
Erigeron strigosus var. calcicola	open limestone glades	frequent			x
Erythronium albidum	mesic sinkholes and pits	scarce		x	x
Erythronium americanum	mesic sinkholes, pits, and forests	infrequent			x
Euonymus atropurpureus	mesic sinkholes, pits, and forests	scarce			x
Eupatorium hyssopifolium	open barrens/glades, waste places	occasional		x	
Eupatorium serotinum	roadsides/glades	occasional			
Euphorbia commutata	margins of glades and barrens, dry forests	infrequent			
Euphorbia dentata	open glade margins	occasional			
Euphorbia nutans	open limestone glades	occasional			x
Euphorbia serpens	wet open glade	rare		x	x
Euphorbia spathulata	Successional cedar/hardwoods, glades	scarce			
Fagus grandifolia	mixed hardwood forest	scarce			
Fleischmannia incarnata	moist roadside ditches	occasional			x
Forestiera ligustrina	glade periphery and successional forest	common			
Fragaria virginiana	successional pastures, barrens, ruderal	frequent			
Fraxinus americana	Oak-hickory forests, barrens	infrequent			
Fraxinus quadrangulata	dry-mesic mixed cedar/hardwood forest	frequent			
Galactia volubilis	dry barrens, roadsides	occasional		x	x
Galinsoga quadriradiata	old roadsides	rare	x		

Scientific Name	Habitat(s)	Frequency	Ex[29]	Rec	Coll
Galium aparine	dry-mesic cedar/hardwood forest	frequent		x	x
Galium circaezans	dry-mesic cedar/hardwood forest	scarce		x	x
Galium lanceolatum	cedar/hardwood forest	occasional		x	x
Galium virgatum	glade margins	infrequent			x
Geranium molle	Open disturbed glades, waste places	occasional	x	x	x
Geum canadense	dry woods	infrequent			
Geum vernum	mesic cedar/hardwoods	frequent			
Grindelia lanceolata	open cedar glades	frequent			
Helenium amarum	gladey roadside	rare			
Helenium autumnale	glades/barrens	occasional			
Helianthus hirsutus	open barrens/glades, waste places	occasional			
Helianthus mollis	open barrens/roadsides	scarce			x
Heliotropium tenellum	open limestone glades	common			
Houstonia nigricans	open glades, barrens	common			
Houstonia purpurea	open glade margins	occasional			
Houstonia pusilla	barren margins	scarce			
Hybanthus concolor	mesic-dry cedar/hardwood forest	rare		x	x
Hydrastis canadensis	dry-mesic hardwood forest	very rare		x	x
Hypericum frondosum	dry roadsides, open glades, dry woods	frequent			
Hypericum punctatum	disturbed roadside	rare			
Hypericum sphaerocarpon	open moist glades and barrens	frequent			
Hypoxis hirsuta	open moist glades and forests	frequent			
Impatiens capensis	wet trailside	rare			
Iris sp. cultivated	historical home sites (persistent)	very rare			
Isanthus brachiatus	swaley glades	occasional			
Iva annua	old roadsides	infrequent	x		
Juglans nigra	dry-mesic cedar/hardwood forest	infrequent			
Juncus marginatus	open moist limestone glades	infrequent		x	x
Juncus tenuis	dry ground, clearcut	infrequent			
Juniperus virginiana	glades, barrens, dry-mesic forest	common			
Krigia virginica	open succesional glade	very rare		x	x
Lactuca canadensis	dry disturbed roadsides, glades	infrequent			
Leavenworthia exigua var. exigua	open moist glades	infrequent			x
Leavenworthia stylosa	open moist glades	frequent			
Leavenworthia uniflora	limestone cedar glades	infrequent			
Leersia sp.	pond margins	very rare			
Lespedeza cuneata	dry roadsides, disturbed glades	frequent	x	x	x
Lespedeza intermedia	dry barrens	occasional		x	x
Lespedeza repens	dry barrens	occasional		x	x
Leucospora multifida	seasonally wet places in glades	infrequent			
Liatris spicata	dry cedar barrens/pasture	rare		x	x
Ligusticum canadense	alluvial woods, limestone creek beds	rare		x	x
Ligustrum sinense	wet gladey wash	scarce	x		
Lindera benzoin	mesic-dry forests	scarce		x	x
Linum medium var. texanum	open grassland/barrens	occasional			
Liparis lilifolia	margin of cedar glade/barrens	scarce		x	x
Lobelia appendiculata var. gattingeri	open cedar glades	occasional			
Lobelia inflata	dry woods	very rare		x	x
Lobelia spicata	glade periphery and barrens	frequent			
Lonicera japonica	ruderal, dry-mesic forests	frequent	x		
Lonicera maackii	wet gladey wash	very rare	x	x	x
Lonicera sempervirens	dry-mesic cedar/hardwood forest	occasional			

Scientific Name	Habitat(s)	Frequency	Ex[29]	Rec	Coll
Maclura pomifera	successional woods	scarce			
Manfreda virginicus	limestone glades and barrens	occasional			
Matelea carolinensis	mesic cedar/hardwoods	occasional			
Matelea gonocarpos	mixed hardwood forest	rare			
Mecardonia acuminata	swaley glades	occasional			
Melica mutica	mesic-dry cedar/hardwood forest	occasional			
Melilotus alba	dry roadsides, disturbed glades	frequent	x		
Melilotus officinalis	dry roadsides	frequent	x		
Melothria pendula (?)	waste places, mesic woods	infrequent		x	
Microstegium vimenium	disturbed woods	infrequent	x	x	x
Monarda fistulosa	dry trailsides, roadsides	occasional			
Narcissus pseudo-narcissus (?)	old home site	very rare	x		
Nemophila aphylla	stream corridor, mesic areas	scarce			
Nothoscordum bivalve	moist glades and gladey swales	frequent			
Oenothera fruticosa	periphery of limestone glade	very rare		x	x
Oenothera triloba	dry glades	infrequent			
Onosmodium molle ssp. molle	glade margins	occasional			
Ophioglossum engelmanii	margins of glades and barrens	occasional			
Opuntia humifusa	dry limestone cedar glades	occasional			
Ostrya virginica	dry-mesic forests	occasional			
Oxalis violacea	dry glades and barrens	occasional			
Panax quinquefolius	mesic-dry hardwoods forest	very rare			
Panicum anceps	open barrens, waste places	occasional			
Panicum flexile	open grassland/barrens	occasional			x
Parietaria pensylvanica	shaded limestone outcrops	infrequent			
Parthenium integrifolium	open grassland/barrens	occasional			
Parthenocissus quinquefolia	dry-mesic hardwood forest	frequent		x	x
Paspalum setaceum var. muhlenbergii	open disturbed glades	scarce			x
Passiflora lutea	wooded glade margin	rare			
Pediomelum subacaule	limestone cedar glades	frequent			
Pellea atropurpurea	karst forests, woodlands, and sinks	occasional			
Perilla frutescens	moist roadside ditches	infrequent	x		
Phacelia dubia var. interior	moist successional glades margins	infrequent			
Phegopteris hexagonoptera	mixed hardwood forest	very rare		x	x
Phlox bifida ssp. stellaria	margins of glades/barrens, and roadsides	frequent			
Phlox divaricata	mesic karst forest	scarce		x	x
Phlox pilosa ssp. ozarkana	barrens and roadsides	scarce		x	x
Phryma leptostachya	mesic cedar/hardwoods	infrequent		x	x
Phyla lanceolata	wet glades/wash	rare			
Physalis heterophylla	cedar glades	infrequent			
Pilea pumila	moist woods	infrequent		x	x
Pinus taeda	pine plantations, escaped	scarce	x	x	x
Pinus virginiana	successional pastures, ruderal	scarce		x	x
Plantago aristida	gladey trail	very rare		x	x
Plantago virginica	open glades	occasional		x	x
Platanus occidentalis	alluvial moist woods	rare		x	x
Podophyllum peltatum	mesic-dry cedar/hardwood forest	scarce			
Polygala verticillata var. ambigua	glade periphery and barrens	scarce			
Polygonatum biflorum	mesic-dry hardwood/cedar forest	scarce			
Polygonum sp.	old trail/roadsides	infrequent			
Polygonum hydropiperoides	old roadsides	infrequent			
Polygonum punctatum	alluvial woods, limestone creek beds	occasional			

Scientific Name	Habitat(s)	Frequency	Ex[29]	Rec	Coll
Polygonum virginianum	alluvial woods	rare		x	
Polystichum acrostichoides	stream corridor, moist areas	scarce			
Potentilla simplex	roadsides, barrens	occasional			
Prunella vulgaris	trails and glades	occasional			
Prunus mexicana	margins of glades and barrens, roadsides	occasional			
Prunus serotina	mixed hardwood forest	scarce		x	
Ptelea trifoliata	mesic woods	rare			
Pycnanthemum loomisii	roadsides, disturbed glades	scarce			x
Pycnanthemum tenuifolia	open grassland/barrens	infrequent			
Pyrrhopappus carolinanus	dry roadsides	infrequent			x
Quercus alba	dry-mesic hardwood forest	occasional			
Quercus coccinea	dry hardwood/cedar woods	occasional			
Quercus falcata	oak-hickory forest	scarce		x	
Quercus macrocarpa	cedar/hardwood forest (near road)	very rare			
Quercus marilandica	successional barrens, dry forest	infrequent			
Quercus muhlenbergii	dry forests, margins of glades and barrens	frequent			
Quercus rubra	oak forest	frequent			x
Quercus shumardii	mesic-dry hardwood/cedar forest	occasional			
Quercus stellata	successional barrens, dry forests	occasional			
Quercus velutina	dry hardwood/cedar woods	occasional			
Ranunculus abortivus	successional moist woods	rare			
Ranunculus fascicularis	successional blue ash/cedar woods	infrequent			x
Ranunculus recurvatus	stream corridor, moist areas	infrequent		x	x
Rhamnus carolinana	mesic/dry cedar hardwoods	frequent			
Rhamnus lanceolata	mesic/dry cedar hardwoods	rare			
Rhus aromatica	margins of glades/barrens, dry forest	frequent			
Rhus copallinum	disturbed roadsides/succesional woodlands	infrequent			
Rhus glabra	successional grassland, roadsides	scarce			
Rosa carolina	margins of glades and barrens	occasional			
Rosa setigera	woodland margins, road margins	infrequent			
Rubus arguta	roadsides, barrens	occasional		x	x
Rubus flagellaris	dry woods, roadsides	infrequent			
Rubus occidentalis	roadsides, barrens	rare		x	x
Rudbeckia fulgida var. fulgida	open wet places and woods	frequent			
Rudbeckia triloba	roadsides and trailsides	infrequent			
Ruellia humilis	open glades and barrens	frequent			
Sabatia angularis	open barrens	occasional			
Salvia lyrata	barrens and roadsides	occasional			
Sambucus canadensis	mesic-dry cedar/hardwood forest	scarce			
Samolus valerandii var. parviflorus	mud flats on trails	infrequent			
Sassafras albidum	mixed hardwood forest	scarce			
Clinopodium glabellum	moist glades and gladey swales	frequent			
Schizachrium scoparium	margins of glades, and barrens	common			
Schoenolirion croceum	wet gladey washes, gladey swales	infrequent			
Scirpus pendulus	pond margins	rare			x
Scleria oligantha	open grassland/barrens	infrequent			
Scleria verticillata	open gladey washes	rare		x	x
Scutellaria elliptica var. hirsuta	dry limstone cedar woods	infrequent			
Scutellaria parvula	open glades and margins	frequent			
Sedum pulchellum	open glades, roadsides, karst woods	occasional			
Sedum sp. (cultivated)	old home site	very rare	x		
Senecio anonymus	glade margins and dry forest	occasional			

Scientific Name	Habitat(s)	Frequency	Ex[29]	Rec	Coll
Senecio obovatus	blue ash/cedar woodland	infrequent			
Senna marilandica	open glades/barrens, woodlands	occasional			
Setaria parviflora	old roadside	rare			x
Sherardia arvensis	disturbed roadside	infrequent	x	x	
Silphium trifoliatum var. latifolium	barrens, woodlands	occasional			
Sisyrinchium albidum	open glades and barrens	frequent			
Smilax ecirrata	mesic cedar/hardwoods	very rare		x	
Smilax glauca	open barrens, dry woods	scarce		x	
Solidago nemoralis	open barrens/glades, waste places	frequent		x	x
Spiranthes cernua (magnicamporum?)	trailside, barrens	infrequent		x	x
Spiranthes lacera var. gracilis	open grassland/barrens	occasional			
Spirodela polyrhiza	pond, Matt Knight trail	very rare		x	x
Sporobolus vaginiflorus	open moist glades and barrens	frequent			
Staphylea trifolia	mesic hardwood forest	infrequent		x	x
Stylosanthes biflora	barrens	scarce			
Symphoricarpus orbiculatus	dry-mesic forests, clear cuts	common			
Talinum calcaricum	glades, thin gravels over bedrock	occasional			
Taraxacum officinale	ruderal, successional pastures	infrequent	x	x	x
Tipularia discolor	old cemetary (Edward Cem.)	very rare		x	x
Torilis arvensis	disturbed glades, waste places	infrequent	x		
Toxicodendron radicans	Successional dry-mesic forests	common			
Tragopogon dubius	roadsides, barrens	infrequent	x		
Tridens flavus	open grassland/barrens	occasional			
Trillium cuneatum	mesic-dry hardwood forest	frequent			
Trillium sessile	mesic woods and karst features	scarce			x
Triosteum angustifolium	mesic-dry cedar/hardwood forest	scarce			
Ulmus alata	open glades and barrens, successional woods	frequent			
Unknown graminoid	pond margins				
Urtica chamaedryoides	karst forest	very rare			x
Verbena canadensis	Open glades and barrens, roadsides, successional forests	common			
Verbena urticifolia	trailside in woods	rare			
Verbesina virginica	glade margins and roadsides	frequent			
Viburnum rufidulum	dry forests	occasional			
Vicia minutiflora	dry-mesic hardwood forest	infrequent			
Vinca minor	old home site	rare	x	x	x
Viola eggelstonii	glade margins and barrens	occasional			
Viola palmata	mesic-dry hardwood forest	scarce			
Viola pubescens	stream corridor, mesic areas	very rare		x	x
Viola sororia	mesic-dry hardwood forest	occasional			
Vitis aestivalis?	dry-mesic cedar/hardwood forest	scarce?			
Woodsia obtusa	limestone ledges in sinkhole, forests	occasional			x
Yucca filamentosa	old home site	rare		x	
Yucca flaccida	open disturbed glades and roadsides	infrequent		x	x
Zanthoxylum americanum	mesic karst forest	very rare		x	
Zizia aptera	mesic cedar/hardwoods	infrequent			

Table 2. Mosses Observed or Collected in 2003

Scientific Name	Common Name	Habitat
Anomodon attenuatus	Anomodon moss	Cedar/hardwood forest on limestone around cave opening
Anomodon rostratus	Anomodon moss	Depression in white oak forest on limestone throughout
Atrichum angustatum	Atrichum moss	Cedar/oak forest on soil
Bryoandersonia illecebra	Bryoandersonia moss	Cedar/hardwood forest on limestone around cave opening
Campylium sp.	Campylium moss	Cedar/hardwood forest on limestone around cave opening
Cololejeunea biddlecomiae	A liverwort	Cedar/hardwood forest on limestone around cave opening
Dicranum scoparium	Dicranum moss	Thick cedar woods on soil, leaf litter, stumps
Fissidens cristatus	Fissidens moss	Depression in white oak forest on limestone
Forsstroemia trichomitria	Forsstroemia moss	Cedar/hardwood forest on sapling
Mnium ciliare	A moss	Cedar/hardwood forest on wood and limestone
Pleurochaete squarrosa	Square pleurochaete moss	Limestone, cedar glades and thin woods throughout
Porella pinnata	A liverwort	Limestone around cave opening
Radula sp.	A liverwort	Cedar/hardwood forest on sapling
Thuidium recognitum	Thuidiuim moss	Cedar/hardwood forest on wood and limestone
Tortella humilis	Tortella moss	Limestone, edges of cedar glades

Table 3. Known Rare Plants from Cedars of Lebanon State Forest

Scientific Name	Common name	State/Federal Status
Arabis hirsuta	Western hairy rockcress	Threatened/----
Astragalus tennesseensis	Tennessee milk-vetch	Special Concern/----
Dalea candida	White prairie clover	Special Concern/----
Dalea foliosa	Leafy prairie clover	Endangered/**Endangered**
Echinacea tennesseensis	Tennessee coneflower	Endangered/**Endangered**
Evolvulus nuttallianus	Shaggy dwarf morning glory	Special concern/----
Hydrastis canadensis	goldenseal	Special concern/----
Leavenworthia exigua var. *exigua*	Tennessee glade cress	Special concern/----
Panax quinquefolius	Ginseng	Special concern/----
Phlox bifida ssp. *stellaria*	Glade cleft phlox	Threatened/----
Phlox pilosa ssp. *ozarkana*	Ozark downy phlox	Special concern/----
Schoenolirion croceum	Yellow sunnybell	Threatened/----
Scleria verticillata	Low nut rush	Special concern/----
Talinum calcaricum	Limestone fame flower	Special concern/----
Zanthoxylum americanum	Prickly ash	Special concern/----

Table 4. Expected Management Effects Upon Rare Plants[30]

Definitions of management

Burn – prescribed ecological burn
Rake – doze or root rake
Chop – surface chopping
Thin – thin overstory
Cut – remove overstory
Graze – grazing, livestock
Fence – exclude grazers
Plant – establish plantation
Mowing – includes bushhogging, mechanical
Herbicide – use outside of rare species' growing season for vegetation control

Arabis hirsuta	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy		X	X			X		X		
Detrimental	X								X	
Possibly Beneficial				X			X			X
Undetermined					X					

Astragalus tennesseensis	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy		X	X					X		
Detrimental										
Possibly Beneficial	X			X	X		X		X	X
Undetermined						X				

Dalea candida	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy		X						X		
Detrimental			X			X				
Possibly Beneficial	X			X	X		X		X	X
Undetermined										

[30] Adopted from "Guide to Rare Plants - Tennessee Forestry District 5" by Milo Pyne et al. (1995). These management effects are based upon the field knowledge and experience of the previously stated authors and present authors of this document.

Dalea foliosa	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy		X						X		
Detrimental			X			X				
Possibly Beneficial	X			X	X		X		X	X
Undetermined										

Echinacea tennesseensis	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy		X						X		
Detrimental			X			X				
Possibly Beneficial	X			X	X		X		X	X
Undetermined										

Evolvulus nuttallianus	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy		X				X		X		
Detrimental			X							
Possibly Beneficial				X	X		X		X	X
Undetermined	X									

Hydrastis canadensis	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy	X	X			X	X		X		
Detrimental			X	X					X	
Possibly Beneficial							X			X
Undetermined										

Leavenworthia exigua **var. *exigua***	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy								X		
Detrimental			X							
Possibly Beneficial	X	X		X	X		X		X	
Undetermined						X				X

Panax quinquefolius	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy	X	X			X	X		X		
Detrimental			X	X					X	
Possibly Beneficial							X			X
Undetermined										

Phlox bifida* ssp. *stellaria	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy						X		X		
Detrimental		X	X							
Possibly Beneficial	X			X	X		X		X	X
Undetermined										

Phlox pilosa* ssp. *ozarkana	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy		X			X	X		X		
Detrimental	X		X							
Possibly Beneficial				X			X		X	X
Undetermined										

Schnoelirion croceum	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy		X						X		
Detrimental			X			X				
Possibly Beneficial				X	X		X		X	X
Undetermined	X									

Scleria verticillata	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy								X		
Detrimental						X				
Possibly Beneficial	X			X	X		X		X	X
Undetermined		X	X							

Zanthoxylum americanum	Burn	Rake	Chop	Thin	Cut	Graze	Fence	Plant	Mowing	Herbicide
Destroy		X						X		
Detrimental			X			X			X	
Possibly Beneficial				X	X		X			X
Undetermined	X									

Table 5. Known Rare Animals On and Near the State Forest

Gladeville USGS Topographic Map				Status	
Scientific Name	**Common Name**	**Date**	**Location**	**State**	**Federal**
Gyrinophilus palleucus	Tennessee cave salamander	1970	Pattons Cave near Rockdale, approx. 2.0 miles southwest of the most southwest corner of the State Forest	T	MC
Neotoma magister	Eastern woodrat	1979	State Forest, area abutting the State Natural Area	D	MC
Typhlichthys subterraneus	Southern cavefish	1993 & 2001	Cedar Forest Cave, west side of the State Forest	D	MC
Tyto alba	Barn owl	1988	Suggs Creek community, approx. 4.0 miles northwest of the nearest Forest boundary	D	
Vine USGS Topographic Map					
Gyrinophilus palleucus	Tennessee cave salamander	1993	Jackson Cave, Cedars of Lebanon State Park	T	MC
Chondestes grammacus	Lark sparrow	1994	Old field just outside the entrance to Cedars of Lebanon State Park	T	

State status definitions: D = Deemed in Need of Management, T = Threatened
Federal status definitions: MC = Management Concern (a non-legal status)

Table 6. Amphibian Species Recorded from Wilson County that are Expected on Cedars of Lebanon State Forest

Scientific Name	**Common Name**
Frogs & Toads	
Bufo americanus	American toad
Bufo woodhousei	Woodhouse's toad
Acris crepitans	northern cricket frog
Hyla versicolor/H. chrysoscelis	gray treefrog/Cope's gray treefrog
*Pseudacris crucifer**	spring peeper
Pseudacris triseriata	upland chorus frog
Gastrophryne carolinensis	eastern narrowmouth toad
Rana catesbeiana	bullfrog
Rana clamitans	green frog
Rana palustris	pickerel frog
Rana utricularia	southern leopard frog
Salamanders	
Ambystoma maculatum	spotted salamander
Ambystoma opacum	marbled salamander
Ambystoma tigrinum	tiger salamander
*Desmognathus fuscus**	dusky salamander
*Eurycea cirrigera**	southern two-lined salamander
Eurycea lucifuga	cave salamander
Gyrinophilus palleucus	Tennessee cave salamander
Plethodon dorsalis	zigzag salamander
Plethodon glutinosus	northern slimy salamander
Pseudotriton montanus	mud salamander
Notophthalmus viridescens	eastern newt

*not recorded in Redmond & Scott (1996)
but expected to be on the Forest

Table 7. Notable Cedars of Lebanon State Forest Caves and Sinks

Sources: Barr (1961), Matthews (1971), Wilson (1980), TCS (Oeser/Frost), DNH inventory 2003
Rare Species (TS - *Typhlichthys subterraneus* , NM - *Neotoma magister*, GP - *Gyrinophilus palleucus*)
*Cedars of Lebanon State Park
**not on Forest or Park
{unofficial title}

DNH Name	TCS/Published Name	Source	Latitude (DMS)	Longitude (DMS)	Rare Species	Horizontal (ft)	Vertical (ft)
Cave 01	Birthday Cave	TCS, DNH	360246N	861839W	NM	350	44
Cave 02	Cedar Gate Cave	DNH, TCS	360249N	861750W	NM	140	
Cave 03		DNH	360420N	862439W	NM	45	
Cave 04	Kellys Cave	DNH, TCS	360348N	861807W	NM	207	
Cave 05	Cedar Forest Cave	Matthews, Wilson, DNH, TCS	360523N	862309W	NM, TS	1603	49
Cave 06	Don's Flowstone Hole	TCS, DNH	360238N	861818W	NM	181	47
Cave 07		DNH	360528N	862137W	NM	25	
Cave 08	Birdnest Cave	TCS, DNH	360241N	861818W		57	18
Cave 09		DNH	360601N	862301W		30	
Cave 10	{Blackhaw Slide Cave}	DNH	360501N	862235W	NM	70	
Cave 11	The Inferno	Matthews, Wilson, DNH, TCS	360455N	862252W	NM	142	59
Cave 12		DNH	360223N	862039W		12	
Sink 127	Danger Slit	Matthews, Wilson, DNH, TCS	360459N	862257W	NM	45	73
Sink 130		DNH	360449N	861754W	NM	25	
Sink 134		DNH	360420N	862409W	NM	15	
Sink 140		DNH	360243N	861631W	NM	20	
Sink 168		DNH	360444N	862304W	NM		30
Sink 285	{Raccoon Rump Cave}	DNH	360455N	862450W			

DNH Name	TCS/Published Name	Source	Latitude (DMS)	Longitude (DMS)	Rare Species	Horizontal	Vertical
Sink 286	Aqueduct Cave	TCS, DNH	360305N	861809W		70	26
Sink 288	Crawl Cave	Matthews, Wilson, DNH, TCS	360530N	862119W	NM	152	11
Sink 292		DNH	360239N	861815W			30
Sink 297	Richmond Shop Cave	DNH, TCS	360358N	861806W	NM	52	
Sink 313		DNH	360132N	862047W	NM		
Sink 338		DNH	360546N	862317W	NM	25	30
Sink 349	Burnt House Road Cave*	Wilson, TCS, DNH	360506N	861747W			
Sink 352		DNH	360457N	862327W	NM		
Sink 353	Cedar Tunnel Cave	DNH, TCS	360520N	862417W	NM	100	
Sink 357		DNH	360315N	861751W	NM	15	12
Sink 364		DNH	360144N	861739W	NM	30	
	Abrams Pit	TCS	360454N	861844W		11	32
	Alexandra's Pit	TCS	360305N	861805W	NM	36	61
	Bannockburn Pit	TCS	360317N	861808W	NM	20	50
	Canyon Cave, Ivey's #3**	Wilson, Matthews, TCS	360232N	862044W	TS	426	131
	Cedar Pit Nr1*	TCS	360544N	861945W		62	52
	Cedar Pit Nr2*	TCS	360541N	861930W		54	87
	Cedar Pit Nr3*	TCS	360538N	861920W		52	68
	Deloric Well	TCS	360239N	861721W	NM		
	Desperation Hole	TCS	360143N	861720W		31	38
	Dripstone Grotto**	TCS	360448N	861848W		53	17
	Goat Skull Pit	Matthews	360307N	861800W			30
	Grotto Pit**	Matthews	360528N	861916W			
	Hermit Cave*	TCS	360510N	861930W		169	23
	Hidden Pot (Ivey's Cave #1)*	TCS	360510N	861749W			
	Hurricane Pit	TCS	360320N	861811W	NM	21	31
	Iveys Cave	TCS	360314N	861923W		295	34
	Jackson Cave*	Barr, Wilson, TCS	360508N	861930W	TS, GP	4511	44
	Koeser Pit	TCS	360234N	861723W	NM		
	Loki Cave	TCS	360258N	861751W		54	23

DNH Name	TCS/Published Name	Source	Latitude (DMS)	Longitude (DMS)	Rare Species	Horizontal	Vertical
	Lost IGI Cave	TCS	360238N	861729W	NM	51	49
	Sidewinder Cave	TCS	360247N	861838W		52	25
	Spleenwort Pit	TCS	360320N	861815W		21	31
	The Fissure	TCS	360320N	861811W		23	34
	The Watering Hole	TCS	360445N	861851W			47
	Three Amigos Pit**	TCS	360452N	861847W		20	41
	Toads Pit	TCS	360236N	861721W		39	51

Table 8. Depressions and Sinks Summary for Cedars of Lebanon State Forest

DNH Type	**Modifier**	**Number Recorded**
Depression	Closed-throated	162
Depression	Open-throated, inaccessible	18
Sink	Closed-throated	50
Sink	Open-throated, inaccessible	25
Limestone trench (canyon)		13
Pit		54
Sinking Stream		31
Total:		**353**

Table 9. Recommended Control Methods for Nonnative Invasive Plants

Species	Control Methods							
	Manual Control	Mechanical Control	Prescribed Fire	Grazing	Foliar Application	Cut Treat	Stem Injection	Basal Bark
Severe Threat								
Ailanthus altissima, Tree-of-heaven	X	X			X	X	X	X
Lespedeza cuneata, Sericea lespedeza		X			X			
Ligustrum sinense, Chinese privet	X	X		X	X	X		X
Lonicera japonica, Japanese honeysuckle			X		X	X		
Lonicera maackii, Bush honeysuckle	X	X	X		X	X		X
Microstegium vimineum, Nepalese grass	X	X			X			
Significant Threat								
Bromus japonica, Japanese brome		X	X		X			
Carduus nutans, Musk thistle, nodding thistle	X				X			
Coronilla varia, Crown vetch								
Daucus carota, Wild carrot, Queen Anne's lace	X	X						
Melilotus alba, White sweet clover	X	X	X					
Melilotus officinalis, Yellow sweet clover	X	X	X					
Torilis arvensis, Hedge parsley					X			
Vinca minor, Common periwinkle	X				X			
Lesser Threat								
Cichorium intybus, Cichory								
Tragopogon dubius, Yellow goats-beard								
Watch List A								
Bupleurum rotundifolium, Thoroughwax								